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A MANUAL
OF
PRACTICAL ANATOMY

HUGHES' ANATOMY

PART I

THE UPPER AND LOWER EXTREMITIES

PART II

THE ABDOMEN AND THORAX

PART III

THE HEAD, NECK, AND CENTRAL NERVOUS SYSTEM

A MANUAL
OF
PRACTICAL ANATOMY

BY THE LATE

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IN THREE PARTS

PART II

THE ABDOMEN AND THORAX

Illustrated by 4 Coloured Plates and 151 Figures in the Text

LONDON
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MANUAL OF PRACTICAL ANATOMY

PART II

DISSECTION OF THE ABDOMEN

DISSECTION I

THE LUMBAR REGION[1]

For three days at least the body lies face downwards on the table, its pelvic part propped up by blocks, and the thighs extended from the end of the table. During this period the dissectors of the abdomen have to examine two regions—the lumbar and the ischio-rectal of the perineum. Both are parts of the utmost practical importance. They have to work with, and assist, both the dissectors of the upper and lower extremities—to some extent at least.

The *lumbar region* (fig. 117) is that part of the body which lies between the twelfth rib above and the crest of the ilium below. Its width varies with the proximity of the rib to the crest of the ilium; the distance between them is usually about two and a half inches.

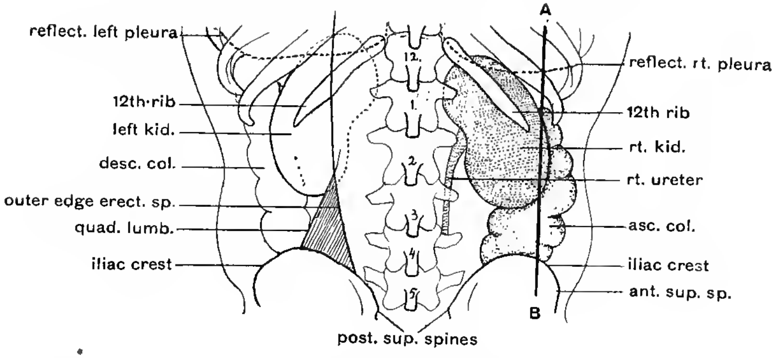
Surface Markings (fig. 117).—The following points should be made out: (1) The crest of the ilium and posterior superior and inferior iliac spines. (2) The tips of the lower dorsal and five lumbar spines. (3) The lower three ribs. The twelfth rib varies much in length; its tip may almost reach the crest of the ilium in some subjects. (4) The prominent rounded outer border of the erector spinæ.

---

[1] It has long been customary to place the body in the lithotomy position during the first two days for the dissection of the perineum. The method described in the text has many advantages: First, the lumbar and sacral regions, now more frequently the seats of operation than the perineum, can be thoroughly examined from behind, instead of being omitted; secondly, the perineum can be more conveniently dissected after the lower extremities are removed; thirdly, now that formalin is the chief ingredient used in preserving subjects for dissection, flexion of the thighs to place the body in the lithotomy position causes rupture of the hamstring and gluteal muscles.

The object of the dissection is to expose the kidney and colon from behind and examine the structures which have to be cut through to reach them. The ascending colon lies in the right lumbar region, the descending in the left. Their position may be indicated by drawing a line vertically upwards from the crest of the ilium an inch to the outer side of the erector spinæ (fig. 117, A, B). The last rib is the best *guide* to the kidney. It crosses the kidney obliquely outwards and downwards; two thirds of the kidney lie below the rib, one third above it. The outer convex margin of the kidney reaches the line of the colon; its lower end reaches within one and a half inches of the iliac crest. The right kidney in women frequently reaches or passes beyond the crest. The structures to be reflected to expose the kidney and colon are shown in fig. 118.

Fig. 117.—The surface markings of the lumbar region.



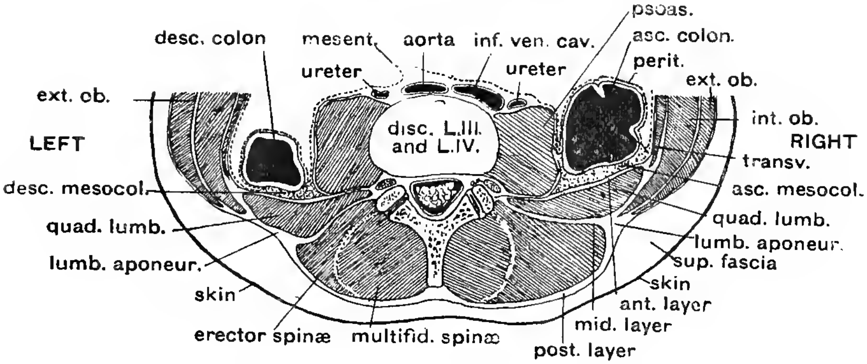
Reflection of the Skin.—Three incisions are made: (1) A median over the lower dorsal and lumbar spines down to the anus. (2) Along the crest of the ilium from the median incision to the anterior superior spine. (3) From the median incision commencing over the last lumbar spine to the posterior border of the axilla, below and external to the acromion process of the scapula.

The skin over the lumbar region is thus marked out into two triangular flaps, which are raised upwards and outwards until the area between the crest of the ilium below and eighth rib above is exposed. The dissectors of the upper extremities assist in the reflection of the skin flaps.

Cutaneous Nerves.—In the superficial fascia are to be found (fig. 119):

(1) The cutaneous branches from the posterior divisions of the first, second, and third lumbar nerves. They appear at the outer border of the erector spinæ, above the crest of the ilium. They spring from the external branches of the posterior divisions (see fig. 120) and end on the gluteal region.

Fig. 118.—Section of the lumbar region of the body, showing the position of the colon and the structures to be divided to expose it. For clearness, the latissimus dorsi is not represented (see fig. 122). (*After Braune.*)

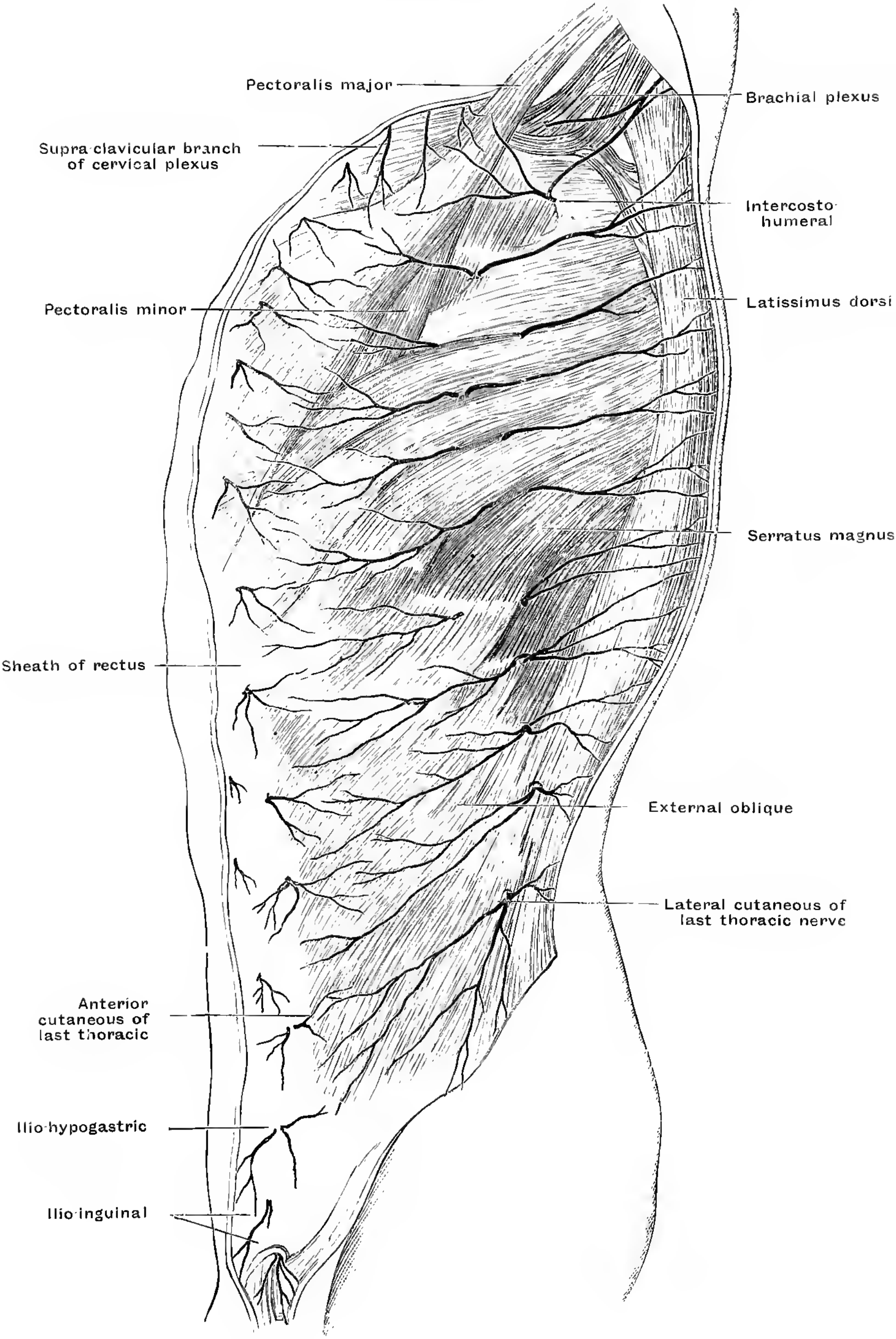


(2) The corresponding cutaneous branches from the lower dorsal nerves. The upper nerves of this series are dissected by the student on the upper extremity.

(3) *Lateral cutaneous branches* from the eighth intercostal to the first lumbar nerve. Each lateral cutaneous nerve (fig. 119) divides into an anterior and posterior branch, which appear separately near the origin of the external oblique and supply the skin on the lateral aspect of the body. The lateral cutaneous (iliac) branch of the twelfth dorsal does not divide; it pierces the external oblique and crosses the crest of the ilium two inches behind the anterior superior spine (fig. 119).

The lateral cutaneous branch of the first lumbar nerve

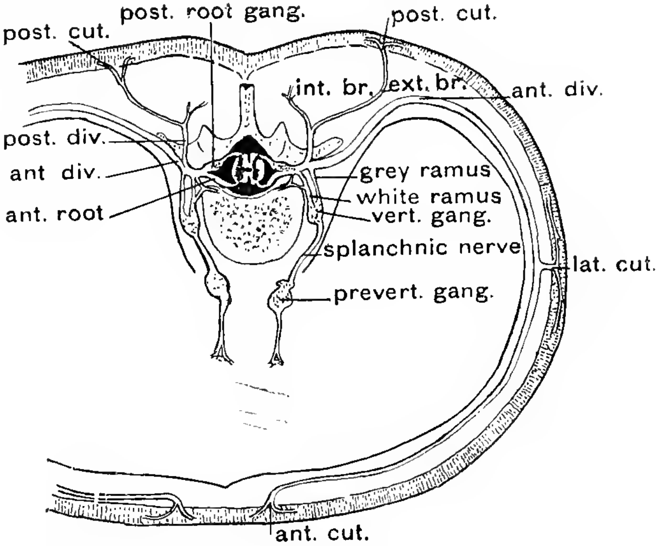
FIG. 119.—LATERAL AND ANTERIOR CUTANEOUS NERVES OF THE ABDOMEN AND THORAX. (*After Henle.*)



(iliac branch of the ilio-hypogastric) crosses the iliac crest a little behind that of the twelfth dorsal.

Petit's Triangle.—A triangular interval should be looked for between the anterior border of the latissimus dorsi behind and the posterior border of the external oblique in front, above the crest of the ilium (fig. 121). This is Petit's triangle; it is situated behind the mid-point of the iliac crest. A hernia or lumbar abscess may appear through it. The borders of the latissimus dorsi and external oblique may meet, so that there is no triangle. This is frequently the case in the male subject.

Fig. 120.—Showing the manner in which the posterior, lateral, and anterior cutaneous nerves arise.



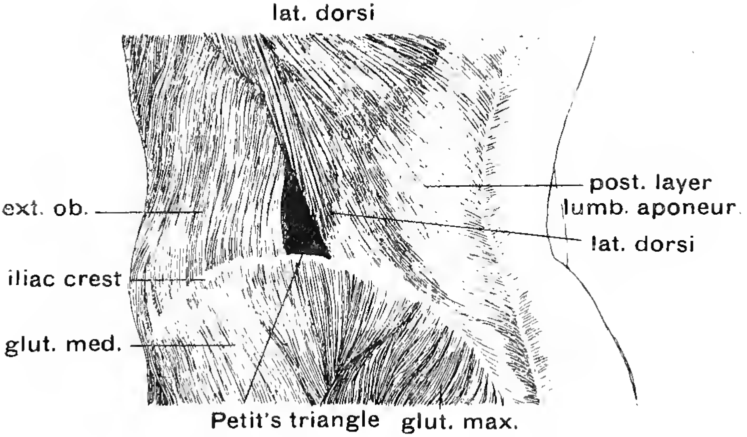
Latissimus Dorsi.—The origin of the muscle from the lower three ribs, posterior third of the iliac crest, and posterior layer of the lumbar aponeurosis is to be cleaned and defined (fig. 121). When this part of its origin has been shown to the dissector of the upper extremity, the attachments are cut through and the muscle reflected upwards.

External Oblique.—The posterior part of the muscle, the part which rises from the outer surfaces of the lowest three ribs and is inserted to the outer border of the anterior half of the iliac crest, is to be cleaned and the posterior border defined (fig. 121). This part of the muscle depresses the lower ribs and acts in expiration.

Lumbar Fascia.—To understand this fascia, it is necessary to study it in such a section of the loins as is shown in fig. 122.

The internal oblique (which can be seen beneath the external oblique in the present dissection) and the transversalis muscle arise by a dense aponeurosis, which stretches from the last rib to the iliac crest. As this aponeurosis passes to be attached to the spine it splits into three layers—*posterior*, *middle*, and *anterior layers* of the lumbar fascia (fig. 118). The *posterior* layer passes to the tips of the lumbar spines, forming a posterior sheath for the erector spinæ. The *middle layer* passes to the tips of the lumbar transverse processes between the erector spinæ and the quadratus lumborum. The *anterior* layer lies in front of the quadratus, and is attached to the bases of the transverse processes on their anterior aspect. Thus the sheath of the erector spinæ is formed by the posterior and middle, and that of the quadratus lumborum by the middle and anterior layers of the lumbar fascia.

Fig. 121.—Diagram of Petit's triangle. (*Balean.*)

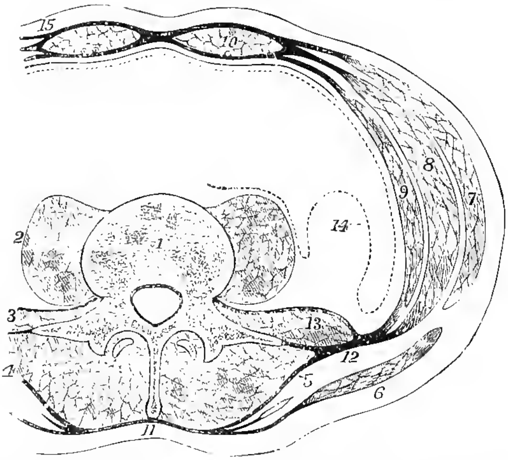


These three layers can be seen by opening the sheath of the erector spinæ (posterior layer) near the outer border of the muscle. By pushing the muscle fibres inwards with the knife-handle the middle layer will be seen. The anterior layer will be encountered in front of the quadratus.

Quadratus Lumborum.—The quadratus lumborum will be studied more minutely afterwards. The quadratus lies deep to the erector spinæ, but above the crest of the ilium its outer border projects at least an inch beyond the erector (figs. 118, 122). Its fibres pass between the posterior fifth of the iliac crest, the last rib and lumbar transverse processes. The colon and kidney lie in front of it.

The aponeurosis of origin of the internal oblique should be cut through at the outer border of the erector spinæ, the incision passing from the last rib above to the iliac crest below. The attenuated transversalis fascia, subperitoneal tissue, and peritoneum lie beneath it (fig. 118).

FIG. 122.—A SECTION OF THE LUMBAR REGION TO SHOW THE THREE LAYERS OF THE LUMBAR FASCIA. (*Cunningham.*)



1. A lumbar vertebra. 2. Psoas magnus muscle. 3. Quadratus lumborum. 4. Erector spinæ. 5. Lumbar aponeurosis. 6. Latissimus dorsi. Between 5 and 6 the serratus posticus inferior is seen. 7. External oblique. 8. Internal oblique. 9. Transversalis. 10. Rectus abdominis. 11. Insertion of the lumbar aponeurosis into the spine of the lumbar vertebra. 12. Lumbar aponeurosis dividing into three layers. 13. The figure is placed on the quadratus lumborum, and has above it the anterior layer of the lumbar aponeurosis, and below it the middle layer. 14. Peritoneum where it covers the kidney. 15. Shows the mode of union of the tendons in the formation of the sheath of the rectus.

Structures on the Anterior Aspect of the Quadratus Lumborum.—The following structures must then be looked for in the fat and connective tissue beneath the fascia at the outer border of the quadratus (fig. 123):

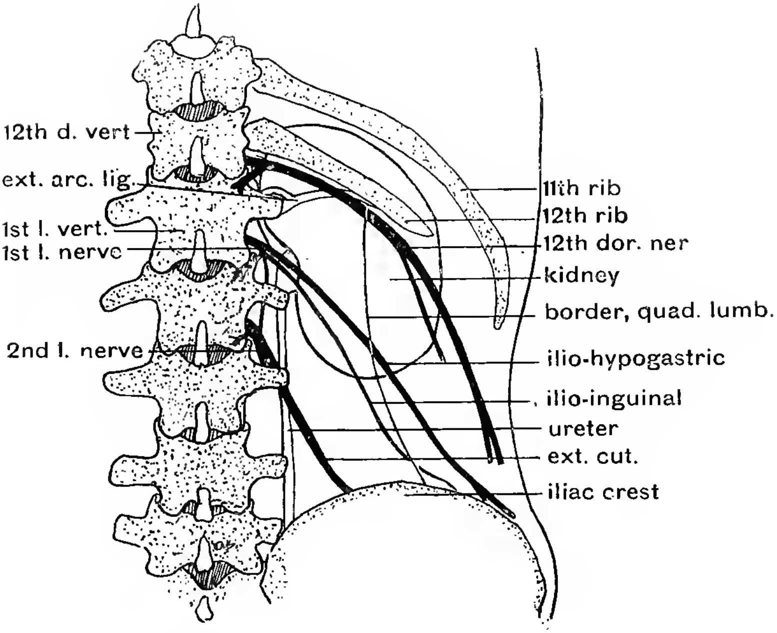
(1) The *twelfth dorsal nerve.* It will be found at the lower border of the last rib. It pierces the aponeurosis of the origin

of the transversalis, and passes forwards between the transversalis and internal oblique.

(2) The *ilio-hypogastric and ilio-inguinal nerves*, both branches of the first lumbar. These pass outwards between the last rib and the iliac crest. They will afterwards be seen beneath the internal oblique.

(3) The *first, second, and third lumbar arteries and veins.* These are commonly of small size, and may not be seen. The *first* lumbar artery accompanies the last dorsal nerve and is the largest of the three. The *others* pass usually on the posterior surface of the quadratus lumborum.

FIG. 123.—THE NERVES BEHIND THE KIDNEY AND COLON IN THE LUMBAR REGION.



(4) The *kidney* (fig. 123) will be felt in a mass of fat and connective tissue in the angle between the last rib and the erector spinæ. The transverse processes of the first and second lumbar vertebræ can be distinctly felt; they lie behind the inner and lower part of the kidney. The fat should be removed so as to expose the infra-costal part of the kidney. The posterior aspect is not covered by peritoneum (fig. 122).

(5) The *ureter* should be looked for in the fat in front of the first and second transverse processes.

(6) When the subperitoneal fat and tissue which lie beneath the aponeurosis of the internal oblique are removed, the outer surface of the *peritoneum*—the lining serous membrane of the abdomen—will be seen.

(7) The *descending colon* on the left side, and the *ascending colon* on the right. If these parts of the bowel are empty, the peritoneum may cover them completely ; but if full—especially as regards the ascending colon—a considerable area of uncovered surface will be found in front of the quadratus lumborum (fig. 118).

To expose the colon and kidney in the loin, the following structures have been cut through (fig. 118): (1) Skin ; (2) subcutaneous tissue and nerves ; (3) parts of the latissimus dorsi and external oblique ; (4) the aponeurosis of the internal oblique and transversalis ; (5) various arteries and nerves ; (6) the transversalis fascia, sub-peritoneal fat and tissue.

The structures thus disturbed should be replaced, stitched in position, and covered by the lower dorsal flap of skin.

DISSECTION II

THE ISCHIO-RECTAL AND ISCHIO-SACRAL REGIONS

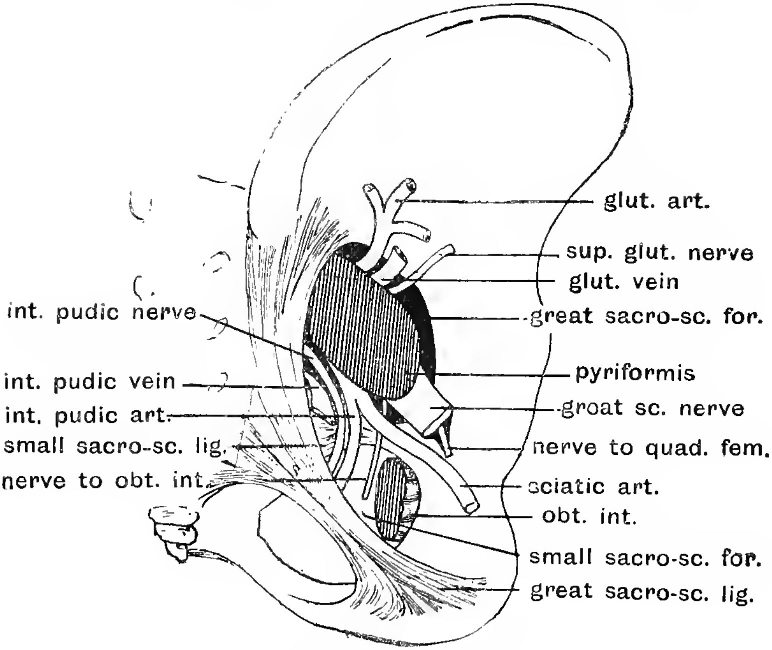
After the men who dissect the lower extremities have reflected the gluteus maximus, cleaned and examined the structures which lie beneath it, and which emerge at the sacro-sciatic foramen (fig. 124), the dissectors of the abdomen commence to examine the region round the anus, coccyx, and sacrum. Many of the structures are common to the abdomen and lower extremities, and dissectors of both parts should be accommodating, the senior helping the junior. The aim of the present dissection is to expose the rectum and its muscles from behind, and thus to obtain a practical knowledge of the structures which are met with by the surgeon in operations on the rectum. Much will be learned, too, of the relationships, nerve supply, and blood supply of the rectum.

Surface Markings.—In going over these, the dissectors should have a pelvis placed in a position corresponding to that of the part examined. The following points are to be noted:

(1) The *anus*, situated midway between and rather behind the ischial tuberosities, and in front of the tip of the coccyx. The distance to each of these three points is a little over $1\frac{1}{2}$ inches.

(2) The *great sacro-sciatic ligament* (fig. 124), passing from the ischial tuberosity to the side of the coccyx, sacrum, and posterior inferior iliac spine. This ligament separates the ischio-rectal from the ischio-sacral region.

Fig. 124.—The formation and contents of the sacro-sciatic foramina.



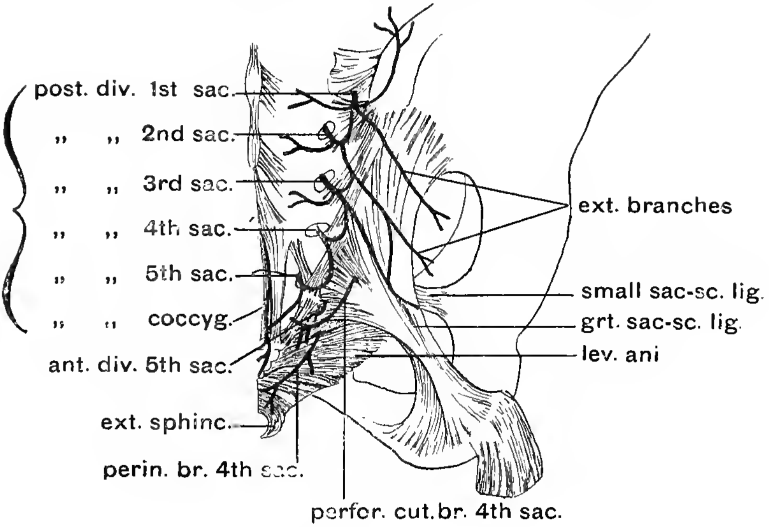
(3) Note the superior cornua of the coccyx, the deficiency of laminæ and spines in the lower one or two sacral vertebræ, and the spinous ridge on the upper three. The lower two sacral vertebræ lie below and beyond the posterior inferior iliac spines.

Reflection of Skin.—The skin has been already reflected from the sacrum and coccyx. It should be removed from the perineum as far forwards (downwards) as the anterior margin of the anus. In the neighbourhood of the anus care must be used in the reflection of the skin, for there the external sphincter and corrugator of the anus lie beneath it.

The *Ano-coccygeal* ligament is an ill-defined band of fibrous tissue which passes from the tip of the coccyx and ends in the posterior border of the anus. It lies between the insertions of the two levator ani muscles.

External Sphincter of the Anus.—The inner fibres form a ring of muscular tissue round the termination of the anal canal. The outer and more superficial fibres arise behind from the tip of the coccyx and the ano-coccygeal ligament. They pass forwards and converge at the central tendinous point of the perineum in front of the anus (Plate XXXIX). It receives its nerve supply from the inferior hæmorrhoidal and perineal branch of the fourth sacral (fig. 125).

Fig. 125.—The nerves of the coccygeal region. (*Balean.*)



Nerves.—(1) *Perineal Branch of Fourth Sacral* (fig. 125). The fourth sacral gives off a perineal branch which will be found as it pierces the coccygeus muscle at the side of the coccyx. It is distributed to the external sphincter and to the skin between the anus and coccyx. It crosses in the fat and connective tissue of the posterior part of the ischio-rectal fossa.

(2) *Perforating Cutaneous Branch of the Fourth Sacral* (fig. 125).—This nerve should be found as it pierces the great sacro-sciatic ligament near the coccyx. Turning round the lower border of the gluteus maximus, it is distributed to a small area of skin near the coccyx.

(3) *Inferior Hæmorrhoidal Nerve.*—In the fat and connective tissue of the ischio-rectal fossa, between the anus and ischial tuberosity, this nerve will be found passing inwards with the inferior hæmorrhoidal vessels (Plate XXXIX). It arises from the internal pudic nerve, and supplies the circum-anal skin and external sphincter.

(4) *Fifth Sacral and Coccygeal Nerves* (fig. 125).—The spinal canal over the fifth sacral vertebra, and probably also over the fourth, is open, the laminæ of these vertebræ being absent. The fibrous and ligamentous tissue over the sacral canal and over the coccyx should be carefully removed. Within the sacral canal soft fatty tissue containing nerve roots will be found. At the termination of the canal, the following nerves should be sought for, four belonging to each side. These are (1) the anterior and posterior divisions of the fifth sacral pair of spinal nerves, (2) the anterior and posterior divisions of the coccygeal pair of spinal nerves.

The four posterior divisions become imbedded in the fibrous tissue over the coccyx, and are hard to trace to their terminations in the skin over the coccyx. The four anterior divisions (two sacral, two coccygeal) are distributed to the circum-coccygeal skin, but take a devious path. They issue from the sacral canal, pierce the structures attached to the side of the coccyx, and appear on the pelvic surface of the coccygeus muscle. This they again pierce to reach the skin.

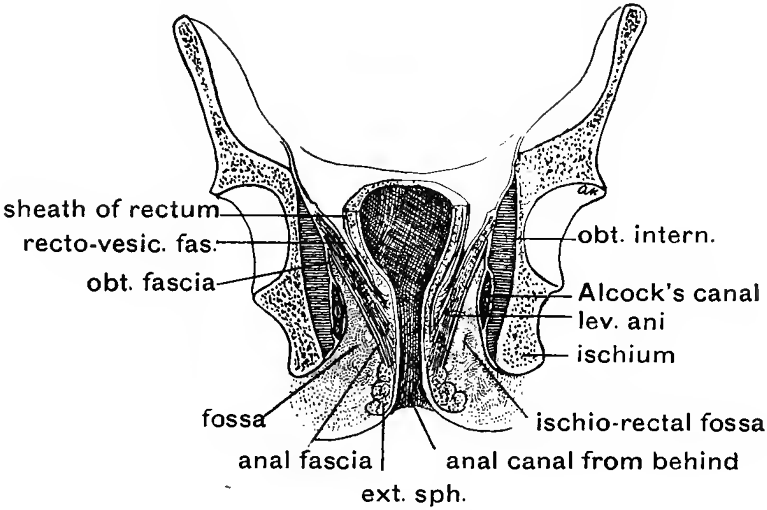
Ischio-rectal Fossa.—The terminal part of the rectum is suspended within the pelvis by a muscular funnel formed by the two levatores ani. Between this funnel, which is now seen projecting in the perineum, and the ischial tuberosity on each side, is a space filled with fat and fibrous tissue, to which the name of ischio-rectal fossa is given (fig. 126). The greater part of this space can now be examined.

BOUNDARIES.—The OUTER WALL of the space should be examined first. The following structures enter into its formation:

(1) The *Obturator Fascia.*—When the fat and contents

of the ischio-rectal fossa are cleaned away from the outer wall with the handle of the scalpel, this thick, strong fascia will be seen (figs. 126 and 199, p. 173). It covers the inner or pelvic aspect of the obturator internus muscle, of which it is the sheath, and forms the outer lining or boundary of the ischio-rectal fossa. The fascia is attached to the inner margin of the ischial tuberosity, insertion of the great sacro-sciatic ligament, and ramus of the ischium; in front it blends with the margin of the triangular ligament.

FIG. 126.—VERTICAL SECTION OF THE ISCHIO-RECTAL FOSSA FROM BEHIND.



(2) The *Great Sacro-sciatic Ligament*, with the lower margin of the gluteus maximus over it, forms the external boundary of the fossa behind the obturator fascia.

(3) The *Small Sacro-sciatic* foramen, between the great and small ligaments, is a hiatus in the outer wall of the fossa (fig. 124). It is the portal by which the vessels and nerves reach the ischio-rectal fossa. The pudic nerve and artery will be seen crossing the ischial spine to enter the fossa, and the pudic vein passing over it to enter the pelvis.

The INNER WALL of the fossa is formed by:

(1) The *Levator Ani Muscle* (fig. 126) and the fibrous tissue or sheath covering its outer aspect—the anal fascia. The

fibres of the levator end on the anal canal and in the ano-coccygeal raphe (Plate XXXIX).

(2) The *Coccygeus* muscle, rising from the ischial spine and ending on the side of the coccyx.

When the fat and fibrous tissue, including the circum-anal tissue, is cleaned away and the muscles forming the inner wall are exposed, the levator ani will be seen to arise from the inner aspect of the obturator fascia (fig. 199, p. 173). At its origin, the anal fascia fuses with the obturator fascia, from the triangular ligament in front to the small sacro-sciatic ligament behind.

SHAPE.—The ischio-rectal space is thus wedge-shaped; its inner and outer walls meet within the pelvis; it ends in a recess in front beneath the base of the triangular ligament and at an angle behind, below the coccygeal insertion of the great sacro-sciatic ligament.

BASE.—The base of the fossa is formed by skin and subcutaneous tissue. The outer fibres of the external sphincter lie in the base.

Contents.—(1) Fat and connective tissue, already removed.

(2) The perineal branch of the fourth sacral nerve, already examined.

(3) The perforating cutaneous branch of the fourth sacral.

(4) The inferior hæmorrhoidal artery and vein (Plate XXXIX).

(5) The superficial perineal vessels and nerves (Plate XXXIX).

(6) The internal pudic artery and vein in Alcock's canal (fig. 126).

(7) The pudic nerve.

Internal Pudic Artery (fig. 127).—The great sacro-sciatic ligament should be removed completely. The pudic artery is then seen crossing the ischial spine. It should be cleaned, its companion vein being removed.

The pudic artery is one of the terminal branches of the anterior division of the internal iliac artery (fig. 203, 19, p. 179). From its origin within the pelvis to its termination as the dorsal artery of the penis, it passes through the following stages:

(1) PELVIC STAGE.—It issues beneath the pyriformis from the great sacro-sciatic foramen (fig. 124). It supplies minor twigs within the pelvis.

PLATE XXXIX.

THE MALE PERINEUM.

FIG. 1.—SUPERFICIAL DISSECTION SHOWING THE VESSELS AND NERVES.

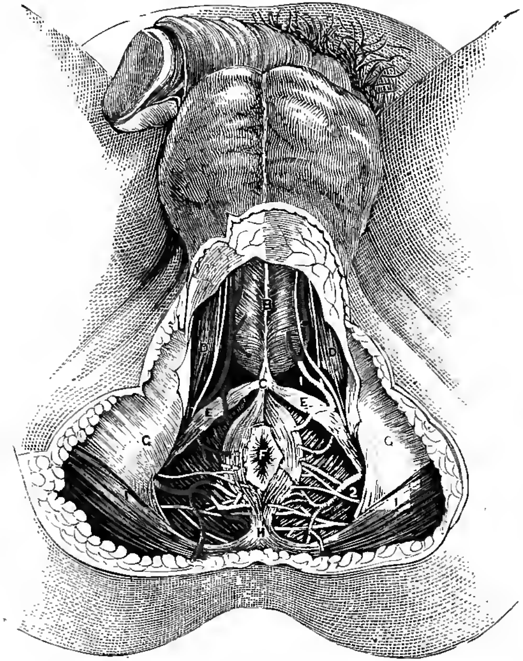
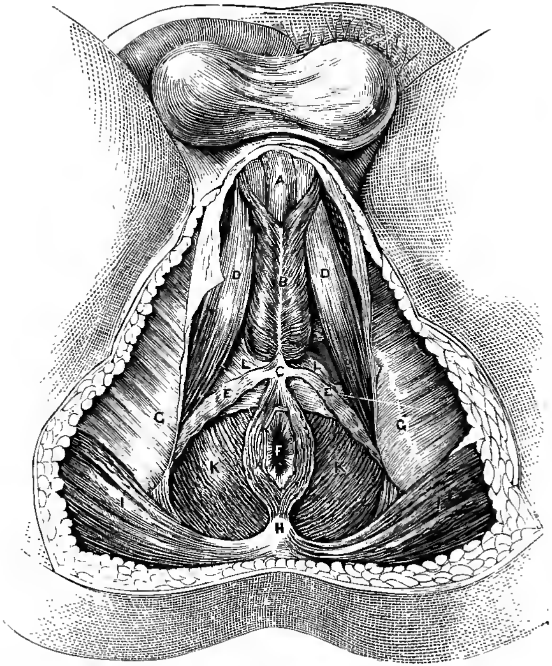


FIG. 2.—DISSECTION SHOWING THE MUSCLES.



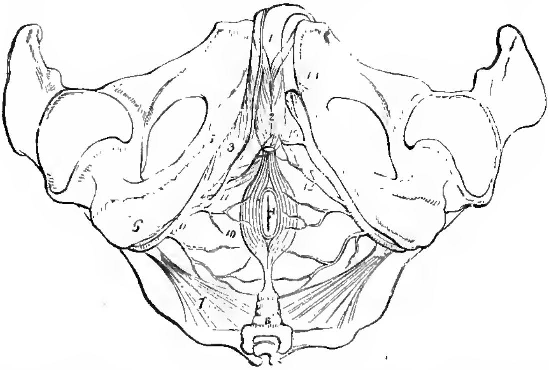
A. Urethra. B. Bulbo-cavernosus. C. Central point of perineum. D. Ischio-cavernosus. E. Transversus perinei. F. Anus. G. Tuber ischii. H. Coccyx. I. Gluteus maximus. K. Levator ani. L. Triangular ligament. 1. Superficial perineal vessels and nerves. 2. Inferior hæmorrhoidal vessels and nerves.

(2) ISCHIAL STAGE.—On the spine of the ischium. The pudic nerve lies internal, and the nerve to the obturator internus external to it.

(3) ISCHIO-RECTAL STAGE.—In the outer wall of the ischio-rectal fossa. Here it is enclosed within the obturator fascia in a fibrous canal (Alcock's) (fig. 126). It enters this stage as it passes through the small sacro-sciatic foramen.

(4) Its final stage between the layers of the triangular ligament will be examined later.

FIG. 127.—SHOWING THE COURSE OF THE INTERNAL PUDIC ARTERY IN THE PERINEUM. (*Wilson.*)



1. The penis; the crus penis of the left side is cut through. 2. Accelerator urinæ muscle. 3. Erector penis. 4. Anus surrounded by the sphincter ani. 5. Rami of ischium and pubes. 6. Tuberosity of ischium. 7. Lesser sacro-sciatic ligament. 8. Coccyx. 9. Internal pudic artery, crossing the spine of the ischium and entering the perineum. 10. Inferior hæmorrhoidal branches. 11. Superficial perineal artery, giving off the transverse artery upon the transversus perinæi muscle. 12. The same artery on the left side cut off. 13. Artery of the bulb. 14. The artery of the corpus cavernosum and the dorsal artery of the penis.

The *Inferior Hæmorrhoidal Artery* arises from the ischio-rectal stage (fig. 127, 10). It crosses the ischio-rectal fossa and ends in the tissues round the anus, anastomosing with the other hæmorrhoidal arteries.

The pudic vein receives perineal and inferior hæmorrhoidal tributaries, and ends in the internal iliac vein within the pelvis. It accompanies the artery.

Pudic Nerve.—In order to see the origin of this nerve, the coccygeus and small sacro-sciatic and ano-coccygeal ligaments should be detached from the sides of the coccyx. The fifth sacral vertebra and coccyx have to be detached from the rest of the sacrum by insinuating the blade of a bone forceps beneath the bone and cutting it through, care being taken that the structures in front of the coccyx and the pudic nerves are not injured. It will then be possible to remove the coccyx and last piece of the sacrum. The fourth piece of the sacrum should then be removed piece-meal.

The pudic nerve will be seen to arise from the third and fourth sacral nerves (see fig. 206, p. 184). In its course the same stages may be recognised as in the artery.

(1) PELVIC STAGE.—Within the pelvis, the pudic nerve lies between the rectum in front and the pyriformis and sacrum behind.

(2) ISCHIAL STAGE.—The nerve crosses the small sacro-sciatic ligament internal to the pudic artery.

(3) ISCHIO-RECTAL STAGE.—As the nerve enters at the small sacro-sciatic foramen it divides into the following:

(*a*) Inferior hæmorrhoidal nerve, already seen terminating round the anus.
(*b*) Perineal nerve.
(*c*) Dorsal nerve of penis.

The two named last pass forwards in Alcock's canal with the pudic artery, one on each side of it (fig. 126).

The Fourth Sacral Nerve.—From this nerve the following branches arise:

(1) Perineal branch (fig. 125).
(2) Perforating cutaneous (fig. 125).
(3) Part of the pudic nerve (fig. 206, p. 184).
(4) Muscular branches to the levator ani and coccygeus.
(5) Nervi erigentes—visceral nerves to the rectum, bladder, prostate, uterus and vagina (fig. 206, p. 184).

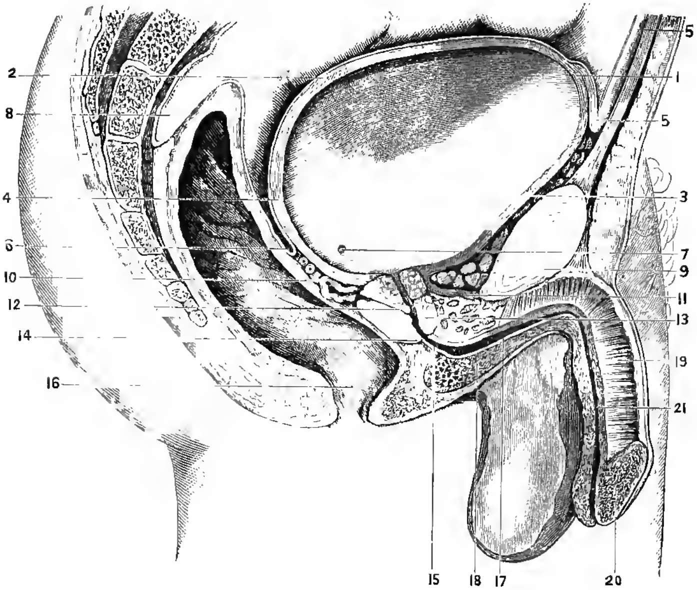
The *pyriformis* should be removed. The rectum is seen to lie on its pelvic or deep aspect.

The Rectum.—Part of the rectum is now exposed. The chief structures which have been removed to expose it are:—(1) The gluteus maximus, (2) sacro-sciatic ligaments, (3) coccyx and part of the sacrum, and (4) pyriformis.

The part of the rectum exposed is the second stage—that part between the third sacral vertebra and the anal canal (fig. 128). It is seen to be surrounded by a sheath of loose fibrous tissue (the rectal fascia), which fuses below with the inner or pelvic sheath of the levatores ani (recto-vesical fascia) (fig. 126). The posterior aspect of this part of the rectum is in contact with the last two vertebræ of the sacrum, the pyriformis, the sacral plexus and nerves, branches of the internal iliac artery and vein, the coccyx, coccygeus and levator ani muscle.

In the fibrous tissue in front of the coccyx and lower part of the sacrum, will be seen : (1) The anterior sacro-coccygeal ligaments ; (2) the middle and lateral sacral arteries and veins ; (3) the ganglion impar of the sympathetic chain (fig. 206, p. 184).

FIG. 128.—SHOWING THE RELATIONSHIP OF THE RECTUM TO THE SACRUM AND PERITONEUM. (*From Sappey.*)



1. Apex of the bladder. 2. Upper surface of the bladder. 3. Lower surface of the bladder. 4. Fundus of the bladder. 5, 5. Urachus making a turn upon itself. 6. End of recto-vesical pouch. 7. Entrance of ureter. 8. Rectum, points to the lower limit of the meso-rectum. 9. Symphysis pubis. Behind this is the space known as the cavum Retzii, filled with loose fat. 10. End of vas deferens and inner part of left vesicula seminalis, indicating the base of the prostate. 11. Anterior true ligament of bladder. 12. Common ejaculatory duct. Above this is the portion of the prostate forming the so-called 'middle lobe.' 13. Prostatic part of the urethra. 14. Apex of the prostate. 15. Membranous part of the urethra. 16. Anal canal. 17. Bulbous part of the urethra. 18. Bulb. 19. Septum pectiniforme. 20. Glans penis. 21. Spongy part of urethra.

On the rectum will be found the leash-like arrangement of the branches of the superior hæmorrhoidal artery. They pierce the muscular coat of the rectum two inches above the anal canal, and end in the sub-mucous plexus in the lower part of the rectum (fig. 218).

The *middle hæmorrhoidal* artery arises on each side from the anterior division of the internal iliac, but its origin is variable (Plate XLII, p. 178). It is usually of small size and ends in the lower part of the second stage of the rectum.

The superior hæmorrhoidal vein joins the inferior mesenteric and its blood thus passes to the portal vein. The middle hæmorrhoidal veins join the internal iliac vein.

Pelvic Peritoneum.—When the fibrous tissue on the rectum is cleaned away, the peritoneum will be found attached to the upper part of the second stage of the rectum (fig. 128). The recto-vesical or Douglas's pouch lies in front of it (fig. 128, 6). The lower half of this stage lies beyond and uncovered by the peritoneum, while its upper half is covered by peritoneum only on its anterior and lateral aspects. From the sides of the upper part, the peritoneum is reflected to the bladder in the male, to the uterus in the female. The first stage of the rectum is completely covered (fig. 128, 8). It will be seen that the lower half of the second stage of the rectum—about two inches in extent—may be removed without opening the peritoneal cavity; but for the complete removal of the upper half the peritoneal cavity must be opened.

By the time the dissectors have finished this region, they will find that the other dissectors on the body also require the body to be turned. They then commence the examination of the abdomen from the front. Before the body is turned they should see that the parts now dissected have been protected by tow and bandages.

DISSECTION III

THE ABDOMINAL WALL

Surface Anatomy.—The *ensiform cartilage* and the extremities of the lowest five ribs as they form the *costal margin* should be distinguished (fig. 129).

Extending from the ensiform cartilage to the *symphysis pubis* is a slight depression, corresponding to the *linea alba*, or line of junction of the aponeuroses of the opposite sides of the abdomen. This is the least vascular part of the abdominal wall, and is consequently the line most frequently chosen for operations within the abdomen. A little below the middle of the linea alba is the *umbilicus*. The portion of linea alba above the umbilicus is much broader than that below.

On each side of the linea alba, the *rectus abdominis*, in muscular subjects, causes a slight elevation, which may be interrupted by three or four transverse depressions, marking the positions of *tendinous intersections* in the muscles (lineæ transversæ). External to each rectus muscle is a slight crescentic depression, the *linea semilunaris*.

At the pubes feel the *crest* and *pubic spine*. Immediately above and external to the spine a slight depression indicates the position of the *external abdominal ring*. To feel the ring, invaginate the skin of the scrotum and push the finger upwards and outwards.

A slightly curved shallow depression, extending from the pubic spine to the anterior superior spine of the ilium, indicates the position of *Poupart's ligament*.

Extending downwards over the pubic crest and the inner end of Poupart's ligament, the *spermatic cord* may be felt in the male, as it emerges from the external abdominal ring and enters the scrotum. At the back of the cord the vas deferens can be distinguished by its wiry feel. A point a little above ($\frac{1}{2}$ inch) the middle of Poupart's ligament marks the position of the *internal abdominal ring*.

Regions of the Abdomen.—For convenience of description the abdomen is divided into certain regions by the following lines (fig. 129) :

(*a*) Vertical lines passing along the outer margin of the rectus abdominis of each side (lineæ semilunares).

(*b*) Two transverse lines, the upper of which passes across the abdomen opposite the convexity of the tenth costal cartilages, the lower one across the abdomen half an inch above the anterior superior iliac spines. The upper line is on a level with the lower border of the second lumbar vertebra, and the lower line on a level with the body of the fifth.

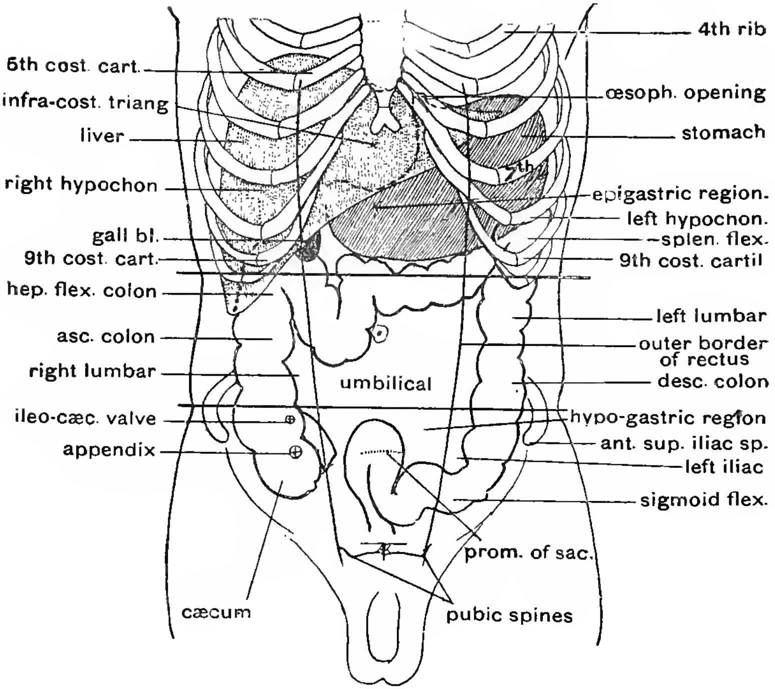
By means of these lines the abdomen is subdivided into nine regions, the mesial ones being an upper or *epigastric*, a middle or *umbilical*, and a lower or *hypogastric*.

The lateral areas, enumerated from above downwards, are the *hypochondriac*, the *lumbar*, and the *iliac*.

Layers in the Abdominal Wall.—Before commencing the actual dissection of the abdominal wall, the student should obtain a clear idea of the various layers which enter into its formation. These are shown diagrammatically in fig. 122, p. 7, and should be verified during the subsequent dissection.

A. In the *middle line* in front, the surgeon cuts through the following layers in opening the abdominal cavity (fig. 122): (1) The skin and superficial fascia; (2) Linea alba, or ventral fibrous raphe between the two recti; (3) Transversalis fascia and sub-peritoneal tissue; (4) Peritoneum.

Fig. 129.—The regions of the abdomen and their chief contents. (*After Addison.*)



B. If *over the rectus muscle* (fig. 122): (1) Skin and superficial fascia; (2) Anterior sheath of rectus; (3) Rectus; (4) Posterior sheath of rectus; (5) Transversalis fascia and sub-peritoneal fat and tissue; (6) Peritoneum.

C. If over the *lateral wall*, outside the rectus: (1) Skin and superficial fascia; (2) External oblique; (3) Internal oblique; (4) Transversalis; (5) Transversalis fascia and sub-peritoneal tissue; (6) Peritoneum. The lumbar and intercostal vessels and nerves lie between layers 3 and 4 (fig. 132).

It should be borne in mind, too, that in life the muscular abdominal wall exercises a continuous pressure on the abdominal viscera, the arrangement of the muscles being adapted for this purpose. With every *inspiration* the abdominal contents are pressed against the anterior wall by the contraction and descent of the diaphragm; in every *expiration* they are pressed against the diaphragm by the muscles of the abdominal wall. Of the four great muscles which compose the abdominal wall, the rectus forms a broad longitudinal band in front; the external oblique, internal oblique and transversalis, which make up the lateral wall, have their fibres arranged thus: the fibres of the external oblique are directed downwards and forwards; those of the internal oblique upwards and forwards; those of the transversalis, forwards.

REFLECTION OF THE SKIN.—The skin is now to be removed from the abdominal wall, and the cutaneous nerves found in the superficial fascia. An incision should be made round the umbilicus. From this, four incisions should radiate, one to the symphysis pubis, one to the ensiform cartilage, and one on each side transversely outwards to the lateral aspect of the abdomen.

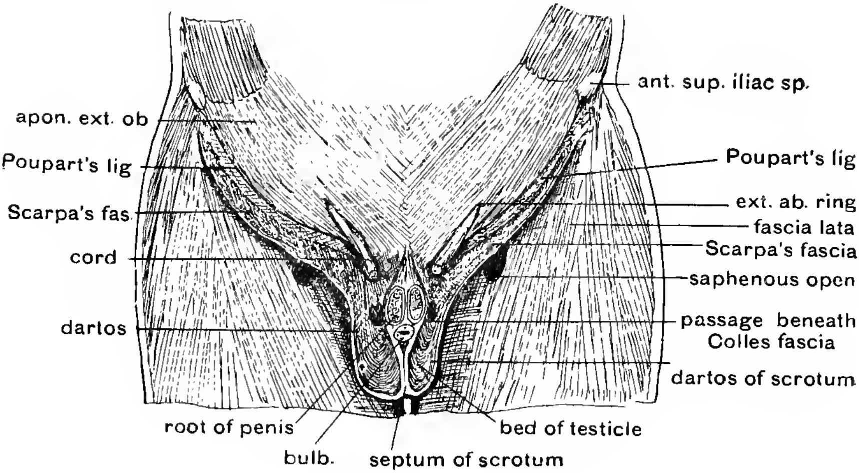
Four flaps of skin can then be raised by commencing at the umbilicus. They should be preserved to act as coverings when the belly is opened.

Superficial Fascia.—Towards the lower part of the abdomen the fascia consists of two layers. The superficial fatty layer (fascia of Camper) in no way differs from the superficial fascia of other parts, and is continued uninterruptedly into the superficial fascia of surrounding regions. The deeper layer, which is present in the groin only, forms the fascia of Scarpa.

Fascia of Scarpa (fig. 130).—To examine this structure, raise the superficial fascia from the abdomen an inch above Poupart's ligament. By introducing the handle of a knife the superficial fascia can be raised along the line of Poupart's ligament from a point below and internal to the anterior superior spine to the scrotum. The handle of the knife cannot be pushed in front of the thigh, because Scarpa's fascia—a deep layer or septum of the superficial fascia—dips down and joins the fascia lata just below Poupart's ligament. The knife-handle may be introduced within the scrotum because the fascia of Scarpa was pressed into it by the descending testicle. The corresponding layer in the scrotum is known as the dartos (fig. 130).

The fascia of Scarpa is membranous in character, and contains some elastic tissue. This layer is attached to the fascia lata immediately below Poupart's ligament, as far inwards as the external abdominal ring; here it is continued downwards over the spermatic cord and scrotum to become continuous with the fascia of Colles in the perineum (fig. 130). This attachment of the deep layer of superficial fascia in the region o Poupart's ligament explains how extravasated urine, which has passed on to the front of the abdomen from the perineum, is prevented from passing down in the subcutaneous tissue of the thigh.

Fig. 130.—Diagram to show the connections of Scarpa's fascia, dartos, and Colles' fascia.

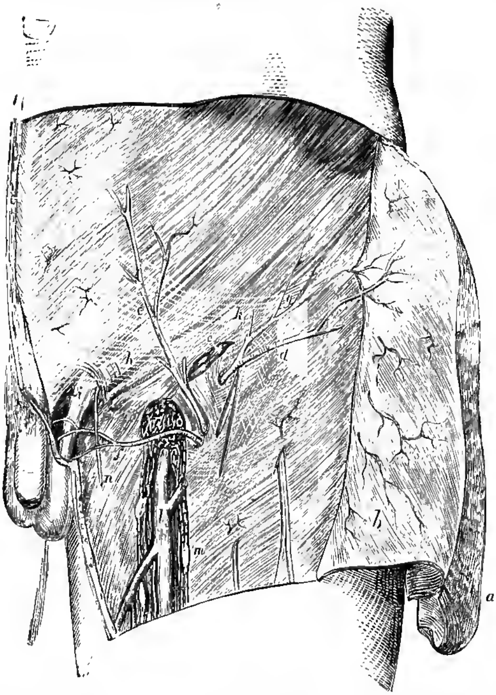


Superficial Inguinal Vessels.—Small branches of the femoral artery, viz. *superficial epigastric, superficial circumflex iliac, superficial external pudic* (fig. 131, *e, d, f*), will be found supplying twigs to the lower part of the abdomen. The corresponding veins open into the internal saphenous vein.

The *superficial epigastric vein* may be of considerable size. Its radicles communicate with veins round the umbilicus and others which join the axillary vein. Valves within it direct the blood towards the groin. In diseases which obstruct the venous circulation in the abdomen, the superficial epigastric vein and its anastomoses may open up into wide channels.

Small branches of the *intercostal* and *epigastric* vessels will be found accompanying the cutaneous nerves.

FIG. 131.—THE STRUCTURES SEEN IN THE GROIN AFTER REFLECTION OF THE SKIN AND SUPERFICIAL FASCIA. (*Wood.*)

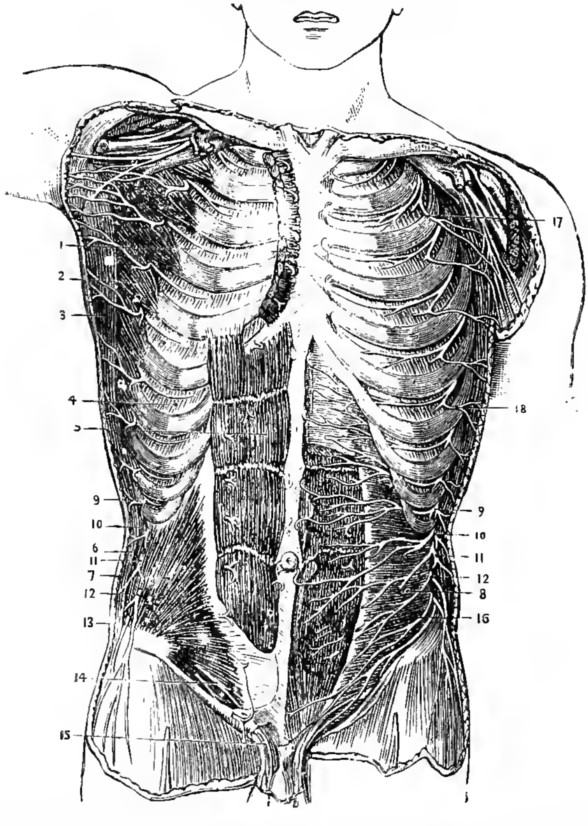


a. Superficial layer of fascia (reflected). *b.* Deeper layer of fascia (reflected), the superficial vessels being left attached to the external oblique. *c.* Inguinal lymphatic glands. *d.* Superficial circumflex iliac artery. *e.* Superficial epigastric artery. *f.* Superior external pudic artery. *g.* Poupart's ligament. *h.* Intercolumnar fascia. *i.* External abdominal ring. *k.* Arciform fibres of external oblique. *l.* Internal saphenous vein. *m.* Femoral lymphatic glands. *n.* Ilio-inguinal nerve. *o.* Saphenous opening.

Cutaneous Nerves (fig. 132).—To find these, scrape the superficial tissue off the sheath of the rectus with the scalpel handle, commencing above and working downwards. The *anterior cutaneous* nerves will be found as they perforate the anterior wall of the sheath of the rectus. The lateral cutaneous nerves have already been found (fig. 119, p. 4).

The skin of the abdomen is supplied by anterior and lateral cutaneous nerves in a manner similar to the skin of the chest (fig. 132). The *anterior cutaneous* nerves are derived from the lower six dorsal nerves and first lumbar nerve (ilio-hypogastric and ilio-inguinal).

FIG. 132.—THE NERVE SUPPLY OF THE ABDOMINAL WALL. (*From Hirschfeld and Leveillé.*)



1. Pectoralis major (cut). 2. Serratus magnus. 3. Latissimus dorsi. 4. Intercostal muscles. 5. Rectus abdominis. 6. Section of obliquus externus. 7. Obliquus internus. 8. Transversalis abdominis. 9, 9. Ninth dorsal nerve. 10, 10. Tenth dorsal nerve. 11, 11. Eleventh dorsal nerve. 12, 12. Twelfth dorsal nerve. 13. Lateral cutaneous branch of first lumbar (ilio-hypogastric). 14. Anterior cutaneous branch of ilio-hypogastric. 15. Anterior cutaneous branch of ilio-inguinal. 16. Ilio-hypogastric and ilio-inguinal nerves. 17. Lateral cutaneous branch of second intercostal nerve. 18. Lateral cutaneous branch of intercostal nerve.

The *anterior cutaneous branches* of the dorsal nerves appear in two sets which pierce the rectus muscle, the inner set piercing its sheath, close to the linea alba, the outer set becoming superficial near the outer border of the rectus muscle (fig. 132).

The *hypogastric* branch of the *ilio-hypogastric* nerve pierces the sheath of the rectus above the external abdominal ring (fig. 132, 14). The *ilio-inguinal* nerve will be found at the external abdominal ring escaping beneath the spermatic cord (fig. 132, 15). It should be followed to its distribution in the skin of the scrotum or pudendum and adjacent part of the skin of the thigh.

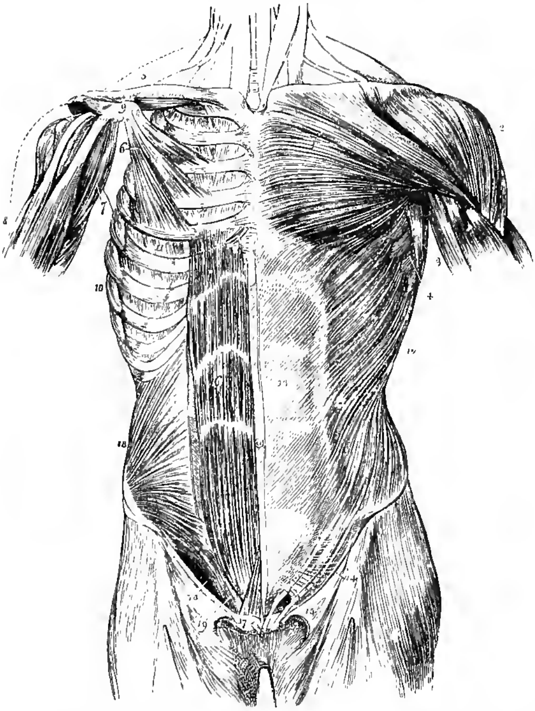
The *lateral cutaneous branches* (fig. 119, p. 4, and fig. 132) of the lower intercostal nerves appear between the digitations of the external oblique muscle, divide into anterior large and posterior smaller branches, and supply the skin of the side of the abdomen. The lateral cutaneous branch of the twelfth dorsal nerve and the iliac branch of the hypogastric nerve do not divide, but pierce the external oblique muscle as single branches just above the crest of the ilium, which they cross to be distributed to the skin in the gluteal region. The branch from the twelfth dorsal nerve lies in front of the iliac branch of the ilio-hypogastric nerve (see fig. 132, 12, 13).

Muscles of the Abdominal Wall.—The external oblique muscle is now to be cleaned. The posterior part of this muscle has already been examined. The cutaneous nerves and superficial fascia should be removed in a systematic manner, by commencing at one border of the muscle and working towards the other. The knife should be plied along the fibres of the muscle, never across them.

External Oblique (fig. 133, 12).—ORIGIN. By eight digitations from the outer surfaces of the eight lower ribs. At its origin the muscle interdigitates with five processes of the serratus magnus and three of the latissimus dorsi.

INSERTION.—(1) The fibres from the lower two or three ribs pass downwards to the outer lip of the anterior half of the iliac crest. (2) The remaining fibres terminate in a broad aponeurosis which covers the greater part of the anterior abdominal wall and meets its fellow of the opposite side in the linea alba from the ensiform process to the symphysis pubis (fig. 133, 13). Its aponeurosis helps to form the anterior sheath of the rectus abdominis. It is also inserted to the anterior superior spine, pubic spine, symphysis, and ilio-pectineal line in the following manner: Inferiorly this aponeurosis stretches from the anterior superior iliac spine to the spine of the pubis, forming the greater part of Poupart's ligament or superficial crural arch. Through the medium of Poupart's ligament, the external oblique is continuous with the fascia lata of the thigh (Plate XL, p. 48). From the inferior surface of the inner end of Poupart's ligament, some

FIG. 133.—THE EXTERNAL OBLIQUE AND RECTUS ABDOMINIS. (*Wilson.*)



1. Pectoralis major. 2. Deltoid; the interval between these muscles lodges the cephalic vein. 3. Anterior border of the latissimus dorsi. 4. Serratus magnus. 5. Subclavius, right side. 6. Pectoralis minor. 7. Coraco-brachialis. 8. Upper part of the biceps, showing its two heads. 9. Coracoid process of the scapula. 10. Serratus magnus, right side. 11. External intercostal muscle of the fifth intercostal space. 12. External oblique. 13. Its aponeurosis; the median line to the right of this number is the linea alba; the curved line to its left, the linea semilunaris; the transverse lines above and below the figure, the lineæ transversæ. 14. Poupart's ligament. 15. External abdominal ring; the margin above the ring is the superior or internal pillar; the margin below the ring, the inferior or external pillar; the curved intercolumnar fibres are seen proceeding upwards from Poupart's ligament to strengthen the ring. The numbers 14 and 15 are placed on the fascia lata of the thigh; the opening to the inner side of 15 is the saphenous opening. 16. Rectus muscle of the right side brought into view by the removal of the anterior segment of its sheath; * posterior segment of its sheath with the divided edge of the anterior segment. 17. Pyramidalis muscle. 18. Internal oblique. 19. Conjoined tendon of the internal oblique and transversalis descending behind Poupart's ligament to the pectineal line. 20. The arch formed between the lower curved border of the internal oblique muscle and Poupart's ligament; it is beneath this arch that the spermatic cord and oblique inguinal hernia pass.

fibres dip backwards to the inner part of the ilio-pectineal line; these constitute *Gimbernat's ligament* (fig. 134, 6).

Just above and slightly external to the spine of the pubes, the fibres of the aponeurosis separate to enclose the *external abdominal ring*, the inner fibres passing as the *inner pillar* of the ring towards the front of the symphysis pubis, where they are attached, interdigitating with the fibres of the inner pillar of the opposite side (fig. 134, 5, 5). The *outer pillar* of this ring is formed by the inner end of Poupart's ligament (fig. 134, 4).

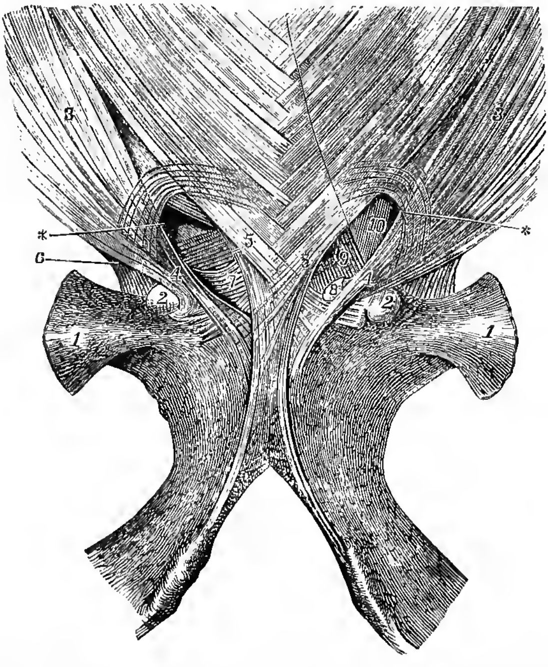
The fibres of the aponeurosis which pass to the lower two inches of the linea alba decussate, those of the right side passing in front of the rectus to the ilio-pectineal line of the left side and *vice versa* (fig. 134, 7). These decussated fibres form the *triangular fascia*, a structure entering into the formation of the inguinal canal. The fascia appears to be continuous at the ilio-pectineal line with the insertion of Gimbernat's ligament.

Inter-columnar Fascia.—Above the inner third of Poupart's ligament some oblique or arched fibres will be seen crossing the aponeurosis of the external oblique (fig. 134). These are the inter-columnar fibres, and are continuous with a thin layer of fascia which stretches across the external abdominal ring between the pillars. This layer is continued down on the surface of the spermatic cord as it emerges from the external ring, and forms the external spermatic or inter-columnar fascia.

External Abdominal Ring (fig. 134).—The external abdominal ring is an oblique elongated gap in the aponeurosis of the external oblique muscle, through which the spermatic cord in the male and round ligament in the female emerge from the inguinal canal. It also transmits the ilio-inguinal nerve. Here, too, an inguinal hernia appears on the surface, and hence the necessity for paying particular attention to the position of the opening in the abdominal wall. The opening is situated just above and external to the spine of the pubes. It is an elongated triangular fissure, the apex of which is directed upwards and outwards. The base of the triangle is formed by the crest of the pubes, the lateral margins or pillars being formed by the fibres of the external oblique. The *inner pillar* is formed by those fibres of the aponeurosis of the external oblique which are inserted into the front of the symphysis pubis. The outer pillar is really the inner end of Poupart's ligament, which is grooved on its upper surface for the reception of the spermatic cord which lies on it.

It will thus be seen that Poupart's ligament—in part at least—Gimbernat's ligament, the triangular fascia or ligament, the intercolumnar fascia, the external and internal pillars of the external abdominal ring are intrinsic parts of the tendon of the external oblique.

FIG. 134.—THE LOWER PART OF THE APONEUROSIS OF THE EXTERNAL OBLIQUE, GIMBERNAT'S LIGAMENT, AND THE EXTERNAL ABDOMINAL RING. (*Luschka.*)



1. Horizontal ramus of pubes. 2. Spine of pubes. 3. Aponeurosis of external oblique. 4. External pillar of abdominal ring. 5, 5. Internal pillar. 6. Gimbernat's ligament. 7. Triangular fascia. 8. The cut end of the same fascia. 9. The conjoined tendon. 10. Transversalis fascia. * External abdominal ring.

ACTION.—The external oblique depresses the lower eight ribs; it compresses the abdominal viscera and forces them against the diaphragm. It thus acts as a muscle of expiration. To some extent it acts as a lateral and anterior flexor of the trunk. It helps to support the abdominal viscera.

NERVE SUPPLY.—From the lower six dorsal nerves.

Dissection.—Detach the external oblique from the surfaces of the ribs (care being taken not to detach the origin of the rectus from the costal cartilages at the same time), from the crest of the ilium, and from the outer half of Poupart's ligament, leaving the muscle intact in the region of the external abdominal ring.

The internal oblique will be recognised by the direction of its fibres which pass upwards and forwards (figs. 132, 7, 133, 18).

Obliquus Internus.—Origin. The internal oblique arises from (1) the outer half of Poupart's ligament, (2) the anterior two thirds of the middle lip of the crest of the ilium, (3) the lumbar aponeurosis (fig. 122, p. 7).

Insertion.—Most of the fibres of the muscle are directed upwards and forwards. The *hinder* fibres are inserted into the lower borders of the costal cartilages of the last four ribs. The *middle* fibres terminate in an aponeurosis which, at the outer border of the rectus, splits into two layers to ensheath that muscle and unite again at the linea alba (fig. 122, p. 7).

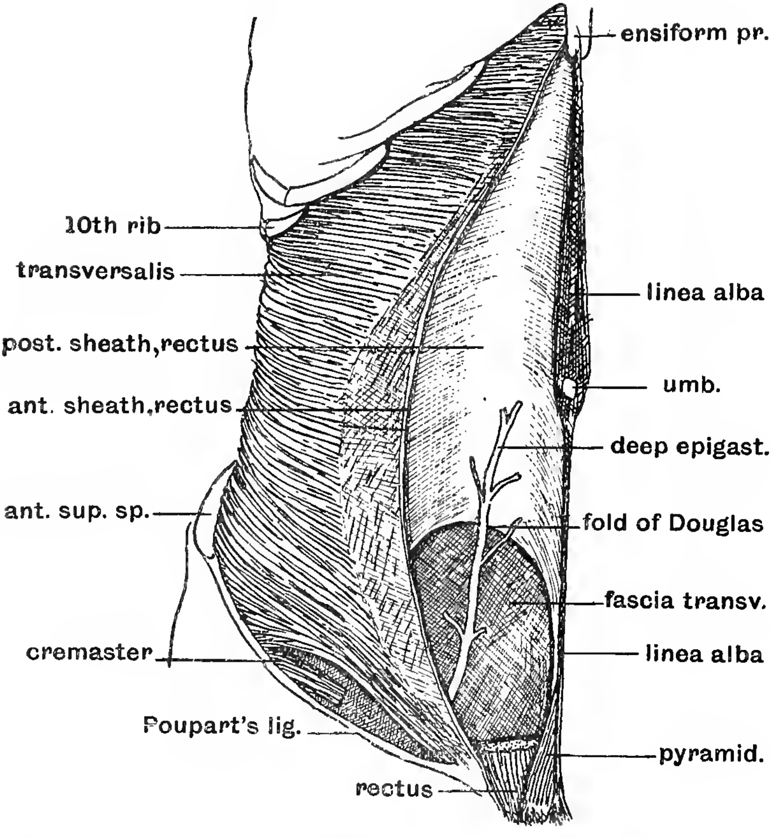
The anterior lamella of the internal oblique is joined by the external oblique, and the posterior lamella by the aponeurosis of the transversalis muscle (fig. 122). The line of splitting of the aponeurosis corresponds to the linea semilunaris, the depression seen at the outer border of the rectus muscle.

Fold of Douglas.—The lower part of the aponeurosis, below a point midway between the pubes and umbilicus, does not split into two layers to form the sheath of the rectus, but passes with the aponeurosis of the transversalis to form only the anterior sheath of the rectus, and thus reach the linea alba conjointly with the aponeurosis of the external oblique. Hence the lower third of the sheath of the rectus is open, the posterior wall of the sheath terminating as an ill-defined crescentic edge behind the outer border of the rectus muscle. The free edge of the sheath—which is formed from the aponeuroses of the internal oblique and transversalis—is known as the fold of Douglas (fig. 135).

The Conjoined Tendon.—The *lower* fibres of the internal oblique, which arise from the outer half of Poupart's ligament, arch inwards over the spermatic cord as it lies in the inguinal canal and join the lowest fibres of the transversalis. The fibres become tendinous and form the *conjoined tendon*, which passes downwards and inwards behind the external abdominal ring to be attached in front of the crest of the pubis and to the ilio-pectineal line (fig. 136, *d*).

Cremaster.—The lowest fibres of the internal oblique which arise from near the middle of Poupart's ligament, internal to those of the conjoined tendon, are prolonged down to the scrotum in the form of looped fibres on the surface of the spermatic cord, forming the *Cremaster muscle* (fig. 135). The muscular fibres are bound together by some connective tissue; the cremasteric fascia is thus formed.

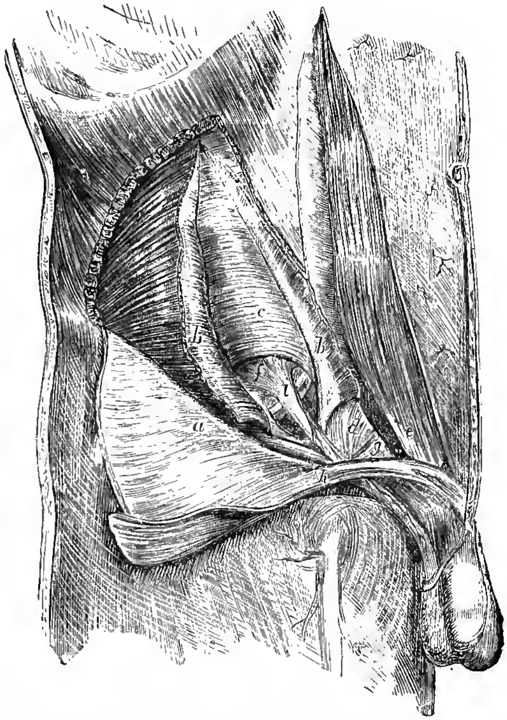
FIG. 135.—THE FOLD OF DOUGLAS.



NERVE SUPPLY.—From the lower dorsal nerves and first lumbar. The cremaster is supplied by the genital branch of the genito-crural nerve.

ACTION.—By the costal fibres the lower ribs are depressed; through these fibres, the costal origin of the diaphragm is stayed to the iliac crest. The conjoined fibres act as compressors of the inguinal canal. The middle fibres compress the abdomen and act in expiration. The cremaster fibres elevate and retract the testicle.

FIG. 136.—DISSECTION OF THE INGUINAL CANAL. (*Wood.*)



a. External oblique (turned down). *b*, *b*. Internal oblique. *c*. Transversalis. *d*. Conjoined tendon. *e*. Rectus, with sheath opened. *f*. Fascia transversalis. *g*. Triangular fascia. *h*. Cremaster. *i*. Infundibuliform fascia.

Descent of the Testicle and Formation of the Inguinal Canal.—The form of the inguinal canal, the arrangement of the structures forming its wall, the position and form of the cremaster muscle, are best explained by a reference to the descent of the testicle.

The testicle is developed behind the peritoneum in the lumbar region of the abdomen, near the body of the last dorsal vertebra. In the seventh month of fœtal life the testicle, with the peritoneum which surrounds and suspends it in the iliac fossa, passes obliquely through the abdominal wall above Poupart's ligament by the inguinal canal, which is formed as the testicle advances. It carries in front of it into the scrotum a prolongation of each of the layers which form the abdominal wall in the inguinal region (fig. 144, p. 46). It impinges against the lower border of the internal oblique muscle and pushes down some of its fibres in front of it to form the cremaster. It carries with it the intercolumnar fascia.

Reflect the internal oblique, all but the fibres which arise from Poupart's ligament and help to form the conjoined tendon. The muscle should be detached from the costal margin, lumbar fascia, iliac crest, and turned forwards. The transversalis muscle, the lower intercostal and lumbar nerves and vessels, are thus exposed (fig. 132, p. 24).

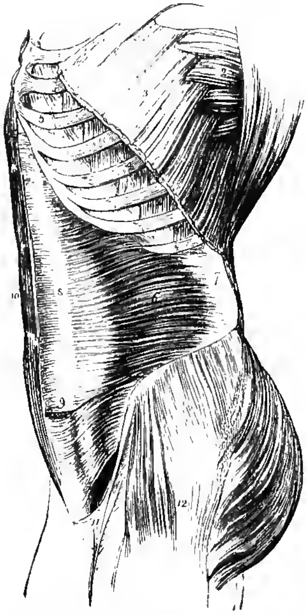
Nerves and Vessels of the Abdominal Wall.—Between the internal oblique and transversalis muscle is a well-marked layer of connective tissue, in which will be found: (1) The lower dorsal nerves coursing forwards; (2) some branches of the deep epigastric artery; (3) a fairly constant ascending branch near the anterior superior iliac spine from the deep circumflex iliac artery; (4) piercing the transversalis muscle just above Poupart's ligament and near the anterior superior spine will be found the ilio-hypogastric and ilio-inguinal nerves.

NERVES IN THE ABDOMINAL WALL (fig. 132, p. 24).—The six lower dorsal nerves, the ilio-hypogastric and ilio-inguinal, pass horizontally forwards between the internal oblique and transversalis, giving off in their course *lateral cutaneous* branches. These become superficial by piercing the internal and external oblique muscles. The main nerves pass forwards, supplying branches to the three abdominal muscles, and enter the sheath of the rectus. They supply branches to the rectus, and having pierced the muscle and the anterior layer of its sheath, terminate superficially as the *anterior cutaneous* nerves. The last dorsal nerve supplies a branch to the pyramidalis muscle.

The lateral cutaneous branches of the last dorsal and ilio-hypogastric nerves pass over the crest of the ilium to the skin in the gluteal region (fig. 132).

Transversalis Muscle (fig. 137, 6).—ORIGIN. From (1) the outer third of Poupart's ligament; (2) the inner lip of the iliac crest in its anterior two thirds; (3) from the fascia lumborum (fig. 118, p. 3); and (4) by six strong slips from the inner aspects of the six lower costal cartilages interdigitating with the costal origin of the diaphragm.

Fig. 137.—The transversalis muscle. (*Wilson.*)



1. Costal origin of the latissimus dorsi. 2. Serratus magnus. 3. Upper part of the external oblique, divided in the direction best calculated to show the muscles beneath without interfering with its interdigitations with the serratus magnus. 4. Two of the external intercostal muscles. 5. Two of the internal intercostals. 6. Transversalis. 7. Its posterior aponeurosis. 8. Its anterior aponeurosis, forming the posterior layer of the sheath of the rectus. 9. Lower part of the left rectus with the aponeurosis of the transversalis passing in front. 10. Right rectus muscle. 11. Arched opening left between the lower border of the transversalis muscle and Poupart's ligament through which the spermatic cord and oblique inguinal hernia pass. 12. Tensor vaginæ femoris, gluteus medius and maximus invested by fascia lata.

Insertion.—Most of the fibres of the transversalis pass horizontally forwards to an aponeurosis which passes behind the rectus, joining the posterior layer of its sheath, and thus reaching the linea alba (fig. 122, p. 7). Opposite the lower third of the rectus the aponeurosis passes in front of the muscle with the internal oblique (see fig. 135, p. 30). The lowest fibres, which arise from Poupart's ligament, arch inwards above the internal abdominal ring to end with fibres from the internal oblique on the *conjoined tendon.* The tendon is attached in front of the crest of the pubis and to the ilio-pectineal line.

Below the arched border of the transversalis muscle the fascia transversalis will be seen extending down to Poupart's ligament (fig. 138).

Nerve Supply.—From the lower six dorsal nerves.

Action.—The transversalis is a compressor of the abdominal cavity. It is remarkably well developed in man, and acts as a muscle of expiration. In defæcation, when the diaphragm is fixed in the position of inspiration, this muscle assists the levator ani in emptying the rectum.

The *fascia lumborum,* by which the transversalis arises, has been already examined (p. 6). It is a strong aponeurosis extending from the last rib to the iliac crest (fig. 137, 7). Traced inwards it divides into three laminæ (fig. 122, p. 7), the *posterior* of which is attached to the tips of the lumbar spines and supra-spinous ligaments; the *anterior* layer is attached to the roots of the lumbar transverse processes blending with the fascia of the psoas. The *middle* layer reaches the tips of the transverse processes and separates the space between the anterior and posterior layers into two compartments. The anterior compartment contains the quadratus lumborum, the posterior containing the erector spinæ (fig. 122).

Rectus Abdominis (figs. 133 and 136).—The anterior wall of the sheath of this muscle is to be laid open by an incision drawn from the eighth costal cartilage to the crest of the pubis. The sheath will be found hard to reflect; it is bound to the tendinous intersections of the muscle.

Origin.—The muscle arises by two heads, the inner one from the front of the symphysis pubis, and the outer, which is broader, from the crest of the pubis.

Insertion.—The fibres pass vertically upwards, expanding as they go, to end on the anterior surfaces of the fifth, sixth, and seventh costal cartilages.

On the anterior surface of the muscle three or four transverse tendinous intersections will be seen. These are the *lineæ transversæ* and are usually three in number, one being found opposite the umbilicus, a second near the ensiform cartilage, and a third midway between the other two. If a fourth be present it will be found below the umbilicus. The intersections are well marked on the anterior surface of the muscle and closely adherent to the anterior layer of the sheath. They barely penetrate to the posterior surface of the muscle, which is quite free from the posterior layer of the sheath.

Nerve Supply.—From the lower six dorsal and first lumbar nerves.

Action.—It is an anterior flexor of the trunk, a depressor of the chest-wall and a compressor of the abdominal viscera, and therefore a muscle of expiration. The muscles are wide above and separated above the umbilicus by a considerable fibrous septum, formed by the linea alba. Below the umbilicus the muscles are thick and narrow, and so close together that, as far as their action is concerned, they may be counted as one.

Sheath of the Rectus (figs. 122, p. 7, and 135, p. 30).—In the greater part of its extent the sheath is formed by the splitting of the aponeurosis of the internal oblique into two lamellæ, the anterior layer being joined by the aponeurosis of the external oblique, the posterior by the transversalis.

Fibres of the transversalis, which rise from the seventh and eighth costal cartilages, pass behind the upper part of the rectus, and the uppermost fibres of the external oblique pass in front. The internal oblique is practically absent above the ninth cartilage. The sheath is deficient behind where the origin of the muscle lies on the costal cartilages.

Over the lower third of the muscle, the aponeuroses of the three muscles pass in front of the rectus, the sheath being deficient behind. Here the muscle is in contact with the fascia transversalis, which covers the deep surface of the transversalis muscle. The posterior layer of the sheath terminates in a free crescentic border a short distance below the umbilicus, forming the *semilunar fold of Douglas*, over which the deep epigastric artery enters the sheath of the rectus, after piercing the fascia transversalis (fig. 135).

Contents of the Sheath.—In addition to the rectus muscles the sheath contains (1) the pyramidalis muscle (when present); (2) the deep epigastric vessels; (3) the superior epigastric vessels; and (4) portions of the lower dorsal nerves which pierce the rectus muscle.

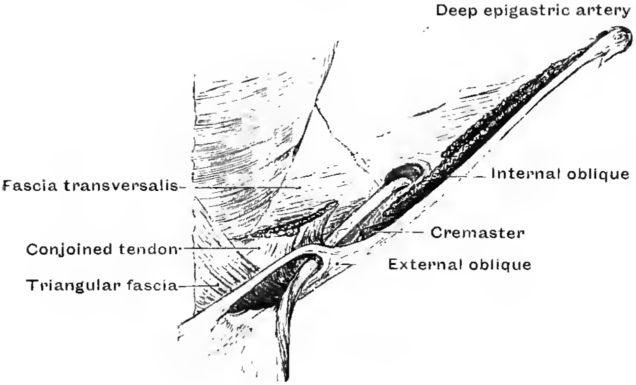
Pyramidalis (fig. 135, p. 30).—The pyramidalis is a small triangular muscle arising from the front of the pubis and inserted into the lower part of the linea alba. It is more or less imbedded in the anterior layer of the sheath of the rectus, and is frequently absent. It acts as a tensor of the linea alba, and is supplied either from the last dorsal or the first lumbar nerve by the ilio-hypogastric.

The Linea Alba.—The linea alba is the surgeon's highway to the abdominal cavity. The structures cut in laying the abdomen open here have been already enumerated (see fig. 122, p. 7).

The linea alba may be regarded as a fibrous septum or ligament stretching from the symphysis pubis to the ensiform cartilage (fig. 135, p. 30). In it the umbilicus is situated. It is part of a ventral median raphe which is found extending from the mouth to the anus. It contains no vessel large enough to give rise to serious hæmorrhage. So narrow is the infra-umbilical part of the linea alba that it is almost impossible for the surgeon to restrict his incision to it. The supra-umbilical part is much wider than the lower part and not so deep. The linea alba is formed by the fusion of the sheaths of the recti in the middle line. Through the sheaths the three flat muscles on each side of the abdominal wall end in it (fig. 122). The fascia transversalis adheres to its deep surface; the superficial fascia is closely bound to its anterior surface.

Fascia Transversalis.—Two portions of this fascia have been already seen, viz. below the lower arched border of the transversalis muscle and behind the lower third of the rectus (fig. 135). The transversalis fascia is a thin fibrous layer which lines the deep surface of the transversalis muscle and helps to form and strengthen the abdominal wall. *Superiorly* it is very thin and continuous with the fascia on the under surface of the diaphragm; *posteriorly* it is continued on to the fascia in front of the quadratus lumborum (anterior layer of the lumbar fascia), and *anteriorly* it is attached to the deep surface of the linea alba. *Inferiorly* the fascia becomes thickened, and is attached (1) to the inner lip of the iliac crest, (2) to the deep surface of the outer half of Poupart's ligament, and (3) to the abdominal surface of Gimbernat's ligament and (4) conjoined tendon (fig. 138). It enters into the formation of the infundibuliform fascia, femoral sheath, and internal abdominal ring.

Fig. 138.—The formation of the inguinal canal. (*Heath.*)



Infundibuliform Fascia.—The testicle as it descended to the scrotum carried outwards a prolongation of the fascia transversalis. This will be found above the middle of Poupart's ligament, passing down with the spermatic cord to form the *infundibuliform fascia* (fig. 136, *f*, *i*).

Femoral Sheath.—Opposite the inner half of Poupart's ligament the fascia transversalis is prolonged beneath that structure to form the anterior layer of the *femoral sheath*. This is carried down on the anterior aspect of the femoral vessels (Plate XL, p. 48).

Internal Abdominal Ring.—The point at which the spermatic cord passes into the funnel-shaped tube of the fascia transversalis is the *internal abdominal ring* (figs. 138 and 139). It may be described as the aperture in the transversalis fascia through which the constituents of the spermatic cord pass into the inguinal canal from the abdominal cavity. It lies about half an inch above the middle point of Poupart's ligament.

Only the inner margin of the internal abdominal ring is at all well marked (fig. 139, *l*). This is a sharp and crescentic fold of the transversalis fascia; the structures entering the inguinal canal turn round it. The outer margin of the internal ring is ill-defined; the loose fibrous tissue of the transversalis fascia at the outer side of the ring passes into the inguinal canal with the cord. The internal ring only becomes well defined when an inguinal hernia passes through it into the inguinal canal with the cord. Such a hernia appears eventually at the external abdominal ring formed by the aponeurosis of the external oblique. The two rings form the inner and outer openings of the inguinal canal.

The *deep epigastric artery* passes obliquely upwards and inwards on the inner side of the internal abdominal ring (fig. 139, *b*). At its origin it lies between the transversalis fascia and peritoneum. It pierces the fascia and passes upwards to the sheath of the rectus.

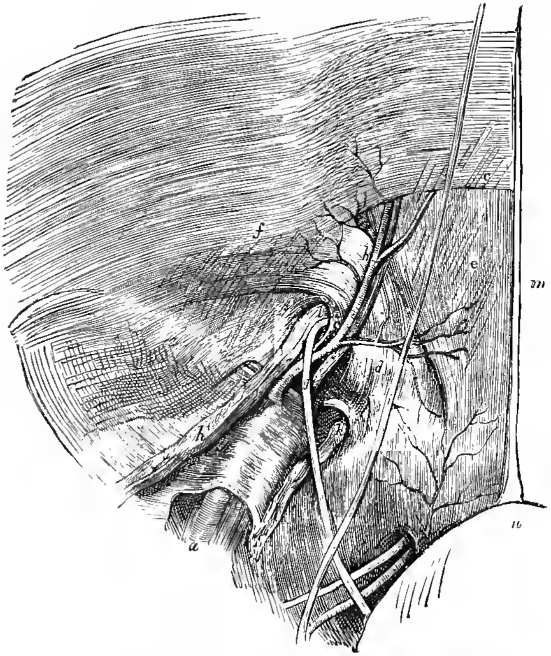
Arteries of the Abdominal Wall (fig. 140).

(1) Intercostal Arteries (10th and 11th).
(2) Lumbar Arteries (1st to 4th).
(3) Superficial Epigastric.
(4) Branches from Musculo-phrenic (from internal mammary).
(5) Superior Epigastric (from internal mammary).

(6) Inferior or Deep Epigastric.
(7) Deep Circumflex Iliac.
(8) Branches from the Ilio-lumbar and Gluteal Arteries. These arteries are to be traced and cleaned one by one.

The *lower two intercostal arteries* pass forwards with the nerves between the transversalis and internal oblique muscles to terminate within the sheath of the rectus, where they anastomose with the deep epigastric artery. Branches from the *musculo-phrenic artery* pass with the intercostal nerves which go to the rectus muscle. Following a similar course will be found the *first lumbar artery*, lying close to the last dorsal nerve.

FIG. 139.—THE INTERNAL ABDOMINAL RING AND ITS RELATIONSHIPS. (*Wood.*)

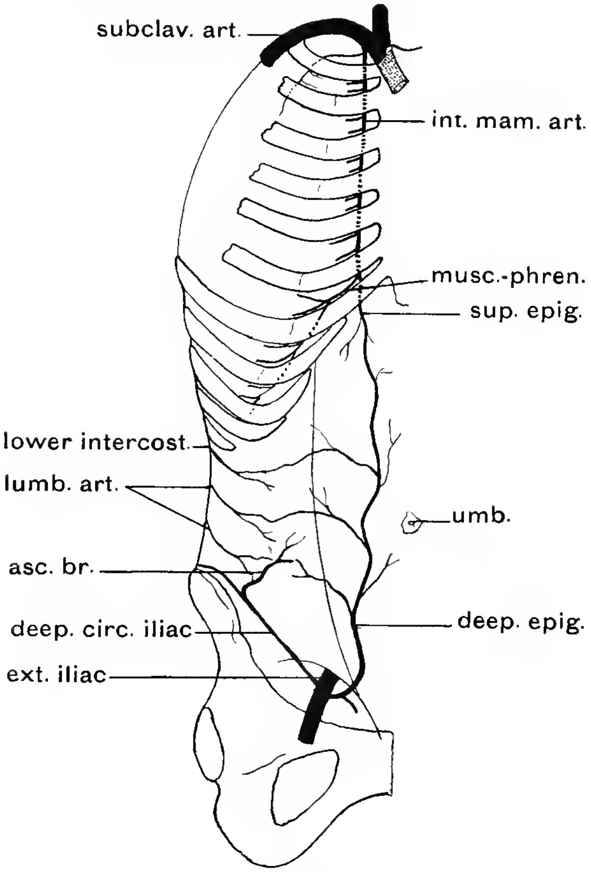


a. External iliac artery. *b.* Epigastric artery. *c.* Border of the posterior part of the sheath of the rectus (fold of Douglas). *d.* Conjoined tendon in the triangle of Hesselbach. *e.* Posterior surface of rectus. *f.* Fascia transversalis. *g.* Vas deferens. *h.* Spermatic vessels. *i.* Obliterated hypogastric artery. *k.* Lymphatics in crural ring. *l.* Internal abdominal ring. *m.* Urachus. *n.* Bladder.

The *Internal mammary artery* (fig. 140) terminates opposite the inner end of the sixth intercostal space by dividing into the musculo-phrenic and superior epigastric arteries. The origin of these two arteries will be seen by removing the terminal inch of the sixth costal cartilage.

The *Musculo-phrenic artery* passes outwards above the costal attachment of the diaphragm behind the seventh, eighth, and ninth costal cartilages. Opposite the tenth cartilage it pierces the diaphragm to terminate in the upper part of the abdominal wall. It supplies anterior intercostal branches to the lower spaces (beyond the sixth).

FIG. 140.—DIAGRAM OF THE ARTERIES OF THE ABDOMINAL WALL. (*Balean.*)



The *Superior epigastric artery* passes behind the seventh costal cartilage to reach the sheath of the rectus by passing between the costal and sternal origins of the diaphragm, external to the ensiform cartilage. In the sheath of the rectus it supplies the muscle and anastomoses with the deep epigastric artery.

Deep Epigastric Artery.—This vessel arises close to the termination of the external iliac artery, immediately above Poupart's ligament (fig. 139). The venæ comites which accompany it should be cleaned away. They end in the external iliac vein.

The artery lies at its origin in the sub-peritoneal tissue and fat, and passes obliquely upwards and inwards in this tissue towards the umbilicus. At first it lies between the fascia transversalis and peritoneum; then it pierces the fascia transversalis, and enters the sheath of the rectus muscle by passing over the fold of Douglas (fig. 135, p. 30). Near its commencement the artery passes on the *inner* side of the internal abdominal ring, being slightly curved at the point where the vas deferens hooks round it to enter the inguinal canal (fig. 144). It might be wounded in making incisions to relieve strangulated inguinal herniæ.

BRANCHES.—(1) *Muscular*, *cutaneous*, and *anastomotic* branches are given off in the sheath of the rectus.

(2) *Cremasteric* to the cremaster muscle and fascia. It arises at the internal abdominal ring and passes to the scrotum in the coverings of the cord.

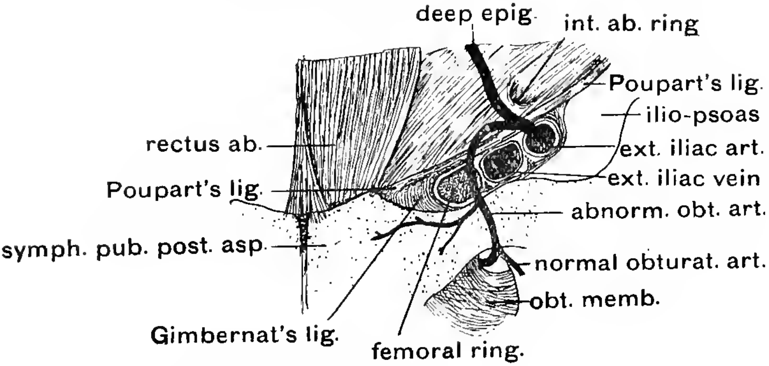
(3) *Pubic* to the back of the pubis. It anastomoses with the pubic branch of the obturator artery.

ABNORMAL OBTURATOR ARTERY.—In three or four bodies of every ten, the *obturator artery* will be found to arise, not from the internal iliac, but from the deep epigastric (fig. 141). This abnormal origin of the obturator artery is to be regarded as due to an enlargement of the normal anastomosis between the pubic branches of the deep epigastric and obturator arteries. When present it reaches the obturator foramen by passing close to the abdominal surface of the crural ring, usually to its outer side (fig. 141). Very rarely it passes on the inner side of the ring, where it is exposed to the danger of being divided in operations on a strangulated femoral hernia.

The **Deep Circumflex Iliac Artery** (fig. 140) arises from the outer side of the external iliac, near the deep epigastric artery and close to Poupart's ligament. It passes outwards in the sub-peritoneal tissue, behind that ligament and the fascia transversalis. It pierces the fascia near the anterior superior spine and comes to lie beneath the transversalis muscle. It passes backwards close to the iliac crest and pierces the transversalis muscle to terminate between it and the internal oblique. The branches anastomose with branches of the ilio-lumbar, gluteal, and lumbar arteries.

Branches.—It gives off *muscular* branches. One of these, the *ascending branch*, is of considerable size (fig. 140). It arises near the anterior superior iliac spine and passes towards the umbilicus between the transversalis and internal oblique. It anastomoses with the inferior and superior epigastric arteries and with the lumbar arteries. This artery is apt to give rise to hæmorrhage in the opening incisions of operations on the cæcum, appendix, or sigmoid flexure.

Fig. 141.—Showing the femoral ring and the origin of the obturator artery from the deep epigastric.



The *deep circumflex iliac vein* crosses the termination of the external iliac artery to terminate in the external iliac vein.

Parietal Peritoneum.—All the layers of the abdominal wall have now been examined, with the exception of the deepest layer of all—the parietal peritoneum.

The fact which will impress the dissector most, and one of practical value, is the loose manner in which the peritoneum is bound to the transversalis fascia by the sub-peritoneal tissue. He will find, especially in the iliac and lumbar regions, that he can strip the peritoneum away from the rest of the abdominal wall with great ease. This is not quite so behind the rectus muscle. There it is still detachable, but not with the same ease as elsewhere. He will see how it is possible for the peritoneum to be carried out by escaping abdominal contents to form a hernial sac. Were the peritoneum firmly adherent to the belly-wall, then a hernial sac, formed by peritoneum, would be an impossibility.

The peritoneum should be incised and its thickness and strength examined. It is a thin, semi-transparent, but tough membrane, with a very considerable degree of elasticity. Its inner surface is smooth, covered by tesselated endothelium, and forms the lining of that great visceral bursa, the peritoneal cavity. Its outer surface is rough and bound down by loose sub-peritoneal tissue. In the sub-peritoneal tissue ramify and anastomose numerous small vascular branches derived from all the vessels of the abdominal wall, and also twigs from the arteries to the retro-peritoneal viscera. These form the SUB-PERITONEAL VASCULAR PLEXUS; by this plexus the parietal peritoneum is nourished.

DISSECTION IV

THE INGUINO-FEMORAL REGION

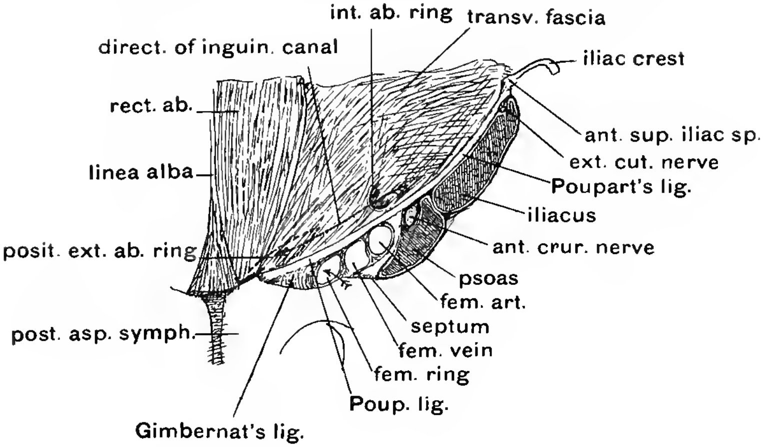
The anatomy and formation of the abdominal wall in the groin are now to be studied. It presents here two weak points at which some of the contents of the belly cavity may escape, causing rupture or hernia. These, unfortunately, are but too common, and their treatment is impossible unless the student grasps now the arrangement of structures in this region of the body.

The two weak spots are the **Inguinal** and **Femoral Canals.** The first lies above Poupart's ligament; the second lies below it. The first is caused by the passage of the testicle through the abdominal wall in its descent from the belly to the scrotum; the second is due to the great size of the crural passage, the space at which the muscles and vessels escape from the belly to the thigh below Poupart's ligament (fig. 142). An empty space—the femoral or crural canal—is left internal to the femoral vein.

STRATA OF THE ABDOMINAL WALL IN THE ILIAC REGION.—The abdominal wall of the iliac region (fig. 129, p. 20), the region above Poupart's ligament, has been already seen to consist of: (1) Skin; (2) superficial fascia made up of two layers—Camper's, the more superficial, and Scarpa's, the deeper layer; (3) the aponeurosis of the external oblique; (4) the conjoined muscle and tendon, made up of the fused lower parts of the internal oblique and transversalis muscles; (5) the transversalis fascia; (6) the peritoneum and sub-peritoneal tissue (figs. 136 and 138).

Hesselbach's Triangle and the Inguinal Fossæ.—A transverse incision should be made from one anterior superior spine to the other, through the dissected structures of the abdominal wall; the peritoneal cavity is thus opened. By pressing the intestines back, and if necessary, by making a vertical incision in the linea alba, a view will be obtained of the inner aspect of the abdominal wall above Poupart's ligament and the pubis.

FIG. 142.—DIAGRAM OF THE CRURAL PASSAGE, FEMORAL AND INGUINAL CANALS.



The following structures are to be noted (see fig. 143):

(1) The *urachus*, a fibrous cord, passing from the apex of the bladder towards the umbilicus, behind the linea alba. It gives rise to a median fold of peritoneum—the urachal fold.

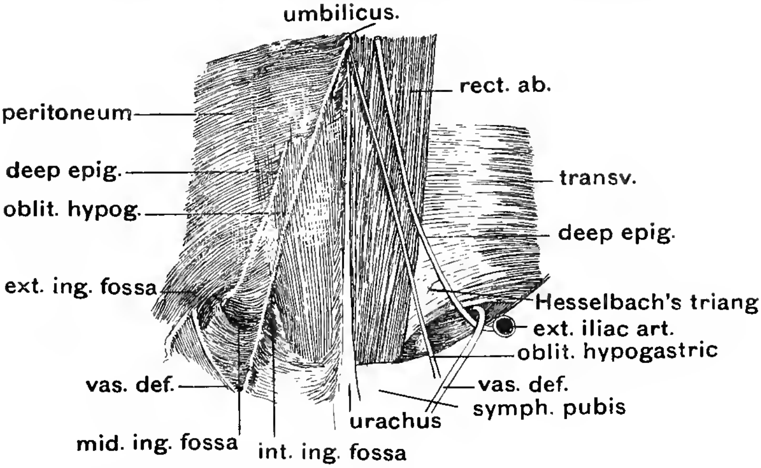
(2) The *obliterated umbilical or hypogastric* arteries, one on each side of the urachus. They converge to the umbilicus, passing behind the rectus muscles as they ascend. They give rise to the two hypogastric folds of peritoneum.

(3) The outer border of the rectus muscle.

(4) The deep epigastric artery, passing also towards the umbilicus.

(5) A slight peritoneal *fossa*—the *external inguinal*—over the *internal abdominal ring*. It lies on the outer side of the deep epigastric artery, above and rather to the outer side of the external iliac vessels. It is situate above the mid-point of Poupart's ligament. The vas deferens and spermatic vessels can be seen converging towards the internal ring beneath the peritoneum.

FIG. 143.—DIAGRAM OF THE INGUINAL FOSSÆ AND HESSELBACH'S TRIANGLE. THE PERITONEUM IS REMOVED ON THE RIGHT SIDE. (*Balean*).



(6) The inner end of Poupart's ligament can be felt passing to the pubic spine (fig. 141).

(7) *Hesselbach's triangle* (fig. 143) is bounded *internally* by the outer edge of the rectus, *externally* by the deep epigastric artery, *below* by the inner half of Poupart's ligament. The hypogastric fold raises the peritoneum covering the triangle and lies between two fossæ. The *middle* inguinal fossa lies in the triangle external to the hypogastric fold of peritoneum; the *internal inguinal* fossa lies internal to the fold (fig. 143). The external abdominal ring lies directly in front of the inner part of Hesselbach's triangle and internal inguinal fossa (fig. 142). Only the peritoneum, transversalis fascia, and conjoined tendon prevent the abdominal contents from protruding at this point (fig. 144).

(8) The *Femoral Ring* is situated below Poupart's ligament and internal to the external iliac vein. A peritoneal fossa may mark its situation. An abnormal obturator artery may be seen passing downwards at its outer side. The boundaries of the ring from within are shown in figs. 141 and 142. The peritoneum can be stripped off easily and its boundaries examined. *In front* is Poupart's ligament, with the transversalis fascia escaping beneath it; *behind* are the horizontal ramus of the pubis, the attachment of the pectineus muscle and fascia lata, and the iliac fascia escaping over them; *internally* is the base of Gimbernat's ligament; *externally* is the femoral vein. Only the peritoneum and sub-peritoneal tissue (septum crurale) prevent the escape of abdominal contents through the femoral ring into the crural canal.

It will thus be seen that there are *three weak points* in the inner aspect of this region of the abdominal wall at which hernia may escape:

(1) The *internal abdominal ring*, lying external to the deep epigastric artery; the point is marked by the external inguinal fossa. Herniæ escaping here are called *oblique* inguinal.

(2) *Hesselbach's triangle* marked by the internal and middle inguinal fossæ. Herniæ starting at either of these two points are called *direct* inguinal. Whether herniæ escape external or internal to the deep epigastric artery, they appear at the same superficial opening, the external abdominal ring.

(3) The *Femoral Ring*. Herniæ escaping by it are called *femoral*. They are most common in women.

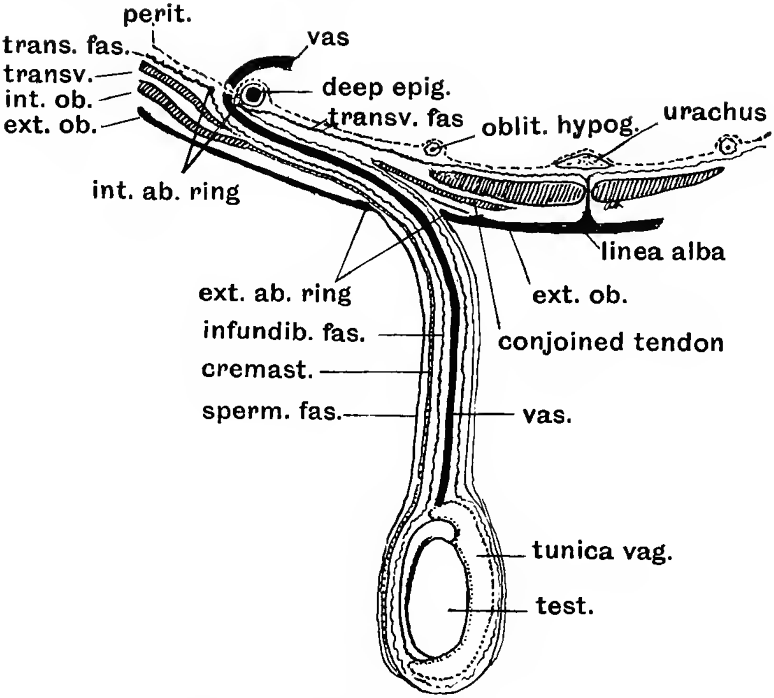
Inguinal Canal.—This canal is now to be studied. The structures entering into its formation have been already dissected (see fig. 138, p. 36).

The inguinal canal is an oblique passage extending from the internal to the external abdominal ring, both of which have been already described, pp. 27, 37. It is about one and a half or two inches in length, and lies immediately above, and parallel to, the inner half of Poupart's ligament (see figs. 138 and 142).

The canal is traversed in the male by the constituents of the spermatic cord enclosed in the tube of infundibuliform fascia derived from the fascia transversalis. In the female it transmits the round ligament of the uterus, which becomes lost in the subcutaneous tissue of the labium majus. The canal is covered *in front* by the integuments, aponeurosis of external oblique, a small portion of the internal oblique and cremaster muscles. *Behind*, the canal is bounded by the fascia transversalis, conjoined tendon, and triangular fascia (fig. 144). The deep epigastric artery crosses obliquely upwards and inwards behind the outer end of the canal. The *floor* is formed by Poupart's and Gimbernat's ligaments.

Above the canal are the lower arched fibres of the transversalis and internal oblique muscles, ending in the conjoined tendon (fig. 136). Behind the inguinal canal lies a portion of *Hesselbach's triangle*, through which direct inguinal herniæ leave the abdomen.

Fig. 144.—Diagram of the inguinal canal and coverings of the cord.



The conjoined muscle with its tendon acts as a partial sphincter of the inguinal canal. It compresses the structures of the spermatic cord against the floor of the canal—Poupart's ligament.

Spermatic Cord (figs. 144 and 149).—When the testicle descends to the scrotum, it carries there its duct—the vas deferens, its vessels and nerves—the spermatic, its peritoneum—the tunica vaginalis. These structures form the spermatic cord. The connection of the tunica vaginalis with the peritoneum is in most cases lost. A prolongation of each of the layers of the abdominal wall of this region is carried in front of the tunica vaginalis. These form the coverings of the cord.

The spermatic cord extends from the internal abdominal ring to the testicle. It contains (fig. 149): (1) The vas deferens; (2) the artery to the vas from the inferior vesical artery; (3) the spermatic artery from the abdominal aorta; (4) the spermatic veins forming the pampiniform plexus and terminating on the right side in the inferior vena cava and on the left side in the left renal vein; (5) spermatic plexus of sympathetic nerves from the aortic plexus; (6) lymphatics which end in the lumbar glands.

In the coverings of the cord are found: (1) Cremasteric artery from the deep epigastric; (2) Genito-crural nerve (genital branch) to the cremaster muscle.

Coverings of the Spermatic Cord (fig. 144).—It is only in a very young subject that these can be seen distinctly separated from one another. In the adult, and especially if there is an inguinal hernia present, the coverings derived from the layers of the abdominal wall are matted together and not separable with any degree of distinctness. The coverings should be examined in the part of the cord lying between the external abdominal ring and upper part of the scrotum.

To expose the constituent structures of the spermatic cord the following coverings have to be cut through (fig. 144): (1) Skin; (2) superficial fascia, including Scarpa's fascia and dartos of the scrotum; (3) the external spermatic or intercolumnar fascia derived from the external oblique; (4) the cremasteric fascia, derived from the internal oblique; (5) infundibuliform fascia, derived from the transversalis fascia. An oblique inguinal hernia is also covered by these layers.

Femoral Ring and Crural Canal.—The structures now to be examined lie in the boundary-line between the belly and the thigh, and the dissectors of both these parts must work together. The following structures should be examined:

(1) *Gimbernat's Ligament* (fig. 141). It is made up of fibres passing from the inner end of Poupart's ligament to the ilio-pectineal line. It is triangular in shape, and about equal in

area to half a postage stamp. Its apex lies at the pubic spine; its base is free, sharp, crescentic, and forms the inner margin of the femoral ring.

(2) *Poupart's Ligament.* Its attachments have been already studied. It is composed principally of aponeurotic fibres of the external oblique, but other elements join it. The fascia lata of the thigh is continuous with it; the internal oblique and transversalis arise from its outer half (fig. 138).

(3) *Crural Passage.* Between Poupart's ligament and the pelvis lies the *crural passage*, in which the following structures are situated (fig. 142): (1) Iliacus and psoas muscles; (2) external cutaneous, anterior crural and crural branch of the genito-crural nerves; (3) femoral artery and vein; (4) the femoral sheath and crural canal; (5) the origin of the pectineus muscle.

A fibrous septum between Poupart's ligament and the ilio-pectineal eminence, situated behind and to the outer side of the femoral artery, divides the crural passage into an outer MUSCULAR and an inner VASCULAR compartment (fig. 142).

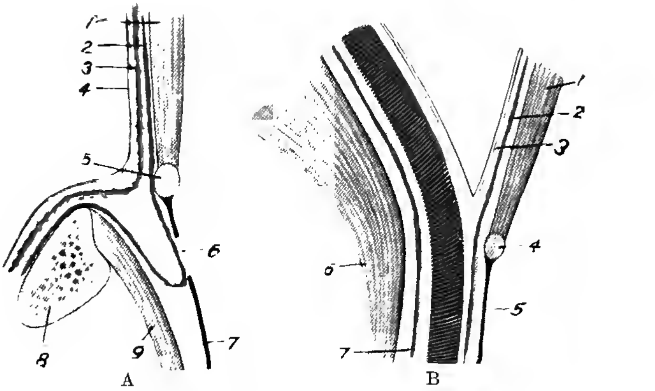
The *Femoral Sheath* (Plate XL). When the iliac fascia, covering the ilio-psoas muscle, and the transversalis fascia, lining the transversalis muscle, are examined, they will be found to join with the outer half of Poupart's ligament and thus completely close the abdominal cavity over the muscular compartment of the crural passage. But in the vascular compartment these two fasciæ are drawn out into the thigh for about an inch on the femoral vessels, forming a short funnel-shaped sheath, to which the name of femoral sheath is given (Plate XL, B).

Crural Canal (Plate XL, A). The femoral vessels do not quite fill the sheath; a small part of the funnel, internal to the vein, is left empty. This forms the crural canal. Its apex is closed below. Its base opens above at the femoral ring.

If a hernia descends through the femoral ring and crural canal, it appears in the groin at the saphenous opening in the fascia lata (Plate XL, A). Inguinal herniæ emerge above Poupart's ligament; femoral herniæ emerge below it; but after it emerges a femoral hernia may turn upwards and become superficial to the ligament.

PLATE XL.

THE FORMATION OF THE FEMORAL SHEATH BY THE ILIAC AND TRANSVERSALIS FASCIÆ.



A. Diagrammatic section of the Crural Canal: **1.** Muscular wall of abdomen. 2. Transversalis fascia. 3. Sub-peritoneal tissue. 4. Peritoneum. 5. Poupart's ligament. 6. Femoral sheath at the saphenous opening. 7. Fascia lata. 8. Pubes. 9. Pectineus.

B. Diagrammatic section at the point of exit of the Femoral Artery: **1.** Muscular wall of abdomen. 2. Transversalis fascia. 3. Peritoneum. 4. Poupart's ligament. 5. Fascia lata. 6. Iliacus. 7. Iliac fascia.

DISSECTION V

THE EXTERNAL GENITAL ORGANS

It is well to examine the external genital organs now; if left until the perineum is dissected, they are apt to become dried and unfit for dissection.

In the Female

The following structures should be noted:

(1) *Labia Majora.* These are rounded folds bounding the *vulval cleft* (fig. 145). Their mesial aspect is covered by mucous membrane; they are covered with hair laterally. In the male, the corresponding folds are fused together to form the scrotum.

(2) *Mons Veneris.* The labia majora meet anteriorly in the mons Veneris, a fibro-fatty eminence over the symphysis pubis. It is covered by hair (fig. 145).

(3) *Posterior Commissure.* Posteriorly the labia majora become attenuated and unite together to form the posterior boundary or commissure of the vulval cleft.

(4) The *Vulval Cleft* is bounded by the labia majora laterally, the mons Veneris in front, and the posterior commissure behind. Into the vulval cleft open the urethra and vagina (fig. 145).

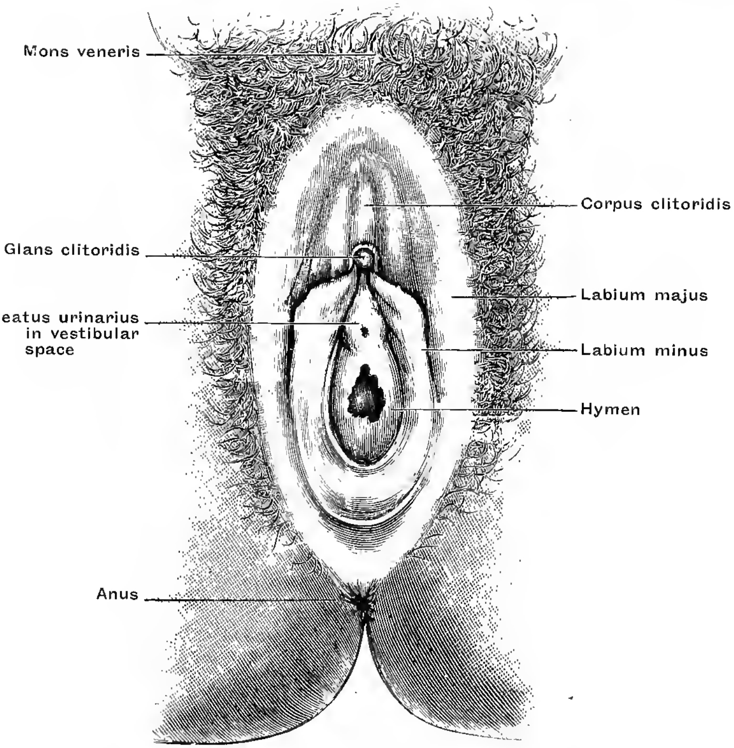
(5) *Labia Minora.* The small lips, two folds covered by mucous membrane, lie within the great, on the sides of the vulval cleft. In the male the corresponding folds unite to enclose the urethra in the penis. Beneath the labia minora are situated the *Bulbi Vestibuli,* masses of erectile tissue, one on each side of the vestibule. The corresponding structures in the male unite to form the corpus spongiosum. In front, each small lip divides into two; the outer divisions unite over the clitoris to form a hood or *prepuce,* the inner unite beneath the glans of the clitoris to form the *frenum* (fig. 145).

(6) *Clitoris.* The clitoris corresponds to the penis of the male. The small lips form a frenum and prepuce for the glans. The body of the clitoris is bent backwards (fig. 145); it is made up of two crura, one on each side, attached to the rami of the

pubes. They correspond to the corpora cavernosa of the male.

(7) *Vestibule.* This is a triangular area in the floor of the vulval cleft. The labia minora bound it laterally; the clitoris is situated at the apex of the space. The anterior margin of the vagina forms its base (fig. 145); the urethra opens near its base.

Fig. 145.—The external genitals of the female. (*From Morris's 'Anatomy.'*)



(8) *Meatus Urinarius.* A catheter should be passed into the bladder. The meatus, marked by slight caruncular elevations, is seen near the base of the vestibule, $\frac{1}{4}$ inch from the margin of the vagina (fig. 145). It is situated in the middle line. The urethra is $1\frac{1}{4}$ inches long.

(9) *Fourchette.* This fold is not always present. It lies in the posterior end of the vulval cleft, deep to the posterior commissure. It represents the united posterior ends of the

labia minora (Blacker). The *fossa navicularis* is a depression in the posterior end of the vulval cleft, between the hymen and the fourchette.

(10) *Vaginal Opening.* The vagina opens in the vulval cleft. Its anterior border forms the base of the vestibule. The lower ends of the divided fold on the roof of the vagina are visible. The posterior border of the opening is marked by the hymen in the young (fig. 145); remnants of the hymen may be seen in the old as carunculæ (Carunculæ myrtiformes). In the vulval cleft, at each side of the vaginal orifice, open the ducts of Bartholin, from glands corresponding to those of Cowper in the male.

(11) *Perineal Body.* When the female perineum is seen in section (fig. 195, p. 167), a wedge-shaped mass of tissue is seen to separate the vagina and anal canal. This mass constitutes the *perineal body.* It is chiefly composed of fibrous and fatty tissue. The sphincter vaginæ begins in it; the sphincter ani (external) ends anteriorly in it; fibres of the levator ani also are inserted here.

At present only the labia majora, mons Veneris, and termination of the round ligaments of the uterus are to be examined. The other structures will be dissected with the pelvic and perineal structures. The margins of the vulval cleft are to be stitched together so as to give a firm basis for the dissection of the labia majora.

TERMINATION OF THE ROUND LIGAMENT OF THE UTERUS.—The termination of this ligament in the labia majora is now to be examined. The ligament corresponds to the gubernaculum testis of the male, the fibro-muscular band which brought about the descent of the testicle. It springs from the upper lateral angle of the uterus (fig. 214, p. 197), and, passing through the inguinal canal, brings with it attenuated strata corresponding to the coverings of the spermatic cord (fig. 144). Its fibres escape at the small external abdominal ring, and are lost in the fibrous tissue of the mons Veneris and labium majus. The round ligament helps to support the uterus. When the fundus of the uterus has fallen backwards, the surgeon may attempt to restore it to position by opening up the inguinal canal and pulling on the round ligament. A considerable vein accompanies the round ligament; through it, the veins of the labia are put in communication with those of the pelvis.

The *Labia Majora and Mons Veneris*. These structures are composed of fibrous tissue containing much fat. When cleaned away they are seen to cover the symphysis pubis and anterior part of the pubic arch.

The *suspensory* ligament of the clitoris, a fibrous strand joining the dorsal aspect of the clitoris to the symphysis, with the origin of the *crura clitoridis* from the inner aspect of the pubic arch may be seen now. Each crus is covered by the *erector clitoridis*, fibro-muscular representatives of the erector penis (ischio-cavernosus) muscle of the male (Pl. XXXIX, p. 14).

External Genital Organs of the Male

The scrotum, the testicle, and the free part of the penis are to be examined now. The deeper structures are left to be dissected with the pelvis and perineum.

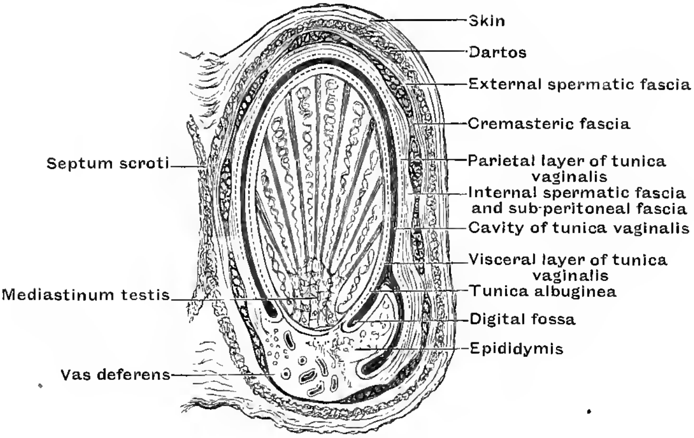
INTRODUCTION OF A STAFF OR CATHETER.—The student should study the length and contour of the male urethra by introducing a catheter or staff. From a section such as is shown in fig. 128, p. 17, he will see that, when the penis is pulled forwards over the abdomen, the contour of the male urethra is that which has been given to the catheter, the deeper part of the urethra forming a segment of a circle under the symphysis pubis. One point he should always keep in mind, viz. that the normal urethra lies exactly in the middle line of the body, and also that its length from meatus to bladder is rather less than eight inches.

The student should practise the introduction of the staff into the bladder. Standing on the left side of the subject, the well-oiled staff is introduced into the urethra with the handle close to the abdominal wall. When the point has reached the perineum, where it can be felt under the pubic arch, a little gentle manipulation will allow the handle to sweep down towards the interval between the thighs, as the point of the staff travels through the membranous and prostatic portions of the urethra into the bladder (fig. 128).

The Scrotum.—When the testicle passes over the front of the pubis it pushes a pouch of skin before it, the combined pouches of opposite sides forming the scrotum. It is divided into two distinct halves by a partition of fascia, the *septum scroti* (fig. 146), the position of which is indicated on the surface of the skin by a median raphe. The *skin* of the scrotum is darkly pigmented and usually highly corrugated, owing to the contraction of the dartos muscular tissue.

The *superficial fascia*, which is continuous with that of the abdomen and perineum, is devoid of fat, and contains a muscular layer—the dartos. This is continuous with Scarpa's fascia above and with Colles's fascia behind (fig. 130, p. 22). The remaining coats of the scrotum correspond with those of the spermatic cord (see p. 47 and fig. 146), of which they form terminal expansions, viz. intercolumnar or external spermatic fascia, cremaster muscle and fascia, and infundibuliform fascia.

FIG. 146.—THE TUNICA VAGINALIS AND COATS OF THE SCROTUM, AND TESTICLE. (*From Morris's 'Anatomy.'*)


Skin
Dartos
External spermatic fascia
Cremasteric fascia
Septum scroti
Parietal layer of tunica vaginalis
Internal spermatic fascia and sub-peritoneal fascia
Cavity of tunica vaginalis
Visceral layer of tunica vaginalis
Mediastinum testis
Tunica albuginea
Digital fossa
Epididymis
Vas deferens

The scrotum contains the testicle, situated in the tunica vaginalis. The parietal layer of the tunica forms the innermost coat of the scrotum (fig. 146).

DISSECTION.—After distinguishing the various layers of the scrotum, the tunica vaginalis should be opened and the testicle exposed.

Tunica Vaginalis (fig. 146).—The tunica vaginalis is a serous sac derived from the terminal portion of the *funicular process* of peritoneum, which descends into the scrotum in front of the testicle. It is thus a saccular diverticulum of the peritoneum. Its communication with the peritoneal cavity usually becomes shut off before birth, the process, from the internal abdominal ring to a point above the testicle, being reduced to a fibrous cord. The funicular process may persist in part or entire. If it remains patent throughout, a hernia may occur into the tunica vaginalis.

The tunica vaginalis consists of a *parietal* layer which lines the scrotum, and a *visceral* layer which covers the testicle and epididymis and is continuous with the parietal at the posterior or attached border of the testis (fig. 146). The inner surface is covered with endothelium and lubricated by a serous fluid. The cavity thus enclosed by the walls of the tunica may become distended with fluid and form a hydrocele.

The Testicle.—When the tunica vaginalis is laid open from the front, by cutting through the parietal layer, the testicle is seen to be attached to its posterior wall. The posterior border of the testicle is outside the tunica vaginalis, and there the duct, vessels, and nerves enter and leave the organ (fig. 146). The parietal layer of the tunica joins the visceral layer at each side of the posterior border of the testis. These two reflected layers form the mesentery of the testis or *mesorchium.*

The testis consists of an oval anterior portion or *body*, and an accessory portion or *epididymis*, which is applied to the outer and posterior part of the body and from which the *vas deferens* is given off.

The **Epididymis** (figs. 146, 147) consists of three parts:

(*a*) An enlarged upper end, the *globus major* or *head*, which receives the vasa efferentia and coni vasculosi, by which it is attached to the upper end of the testis (fig. 147, 6, 7).

(*b*) A somewhat smaller lower extremity, the *globus minor*, which is attached to the lower end of the testicle by some areolar tissue and a fold of the visceral tunic (fig. 147, 9).

(*c*) The *body*, which is free and separated from the testicle on its outer side by a small pouch of the tunica vaginalis, called the *digital fossa* (fig. 146).

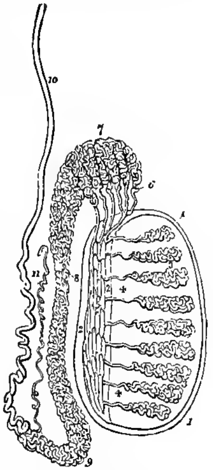
The detached testicle can be referred to its own side, by studying the relation of the digital fossa to the testicle and epididymis. The epididymis lies posteriorly and to the outer side of the testicle, with the globus major upwards; the digital fossa is then to the *outer* side of the testicle. Just underneath the anterior extremity of the globus major are one or two minute bodies, the *hydatids of Morgagni.* They present a great variety in form and position. Usually one is stalked and another sessile. One of them (the sessile) represents the fimbriated end of the Fallopian tube; for it must be remembered that in the earliest stages of the human embryo the organs of both female and male closely correspond. The epididymis consists of a fine tube, over twenty feet in length, neatly coiled up, and is formed from the duct of a primitive kidney—the Wolffian body.

A little above the globus major, beneath the part of the parietal layer of the tunica vaginalis which lies in front of the termination of the spermatic cord, there may occur two or three minute collections of detached tubules, the *organ of Giraldès.* These are remains of some tubules of the Wolffian body. Another Wolffian tubule of considerable length—the *vas aberrans*—occurs in the lower part of the epididymis (fig. 147, 11).

Vas Deferens—the Duct of the Testis.—When the cord is lifted up between the fingers during life as it passes between the external abdominal ring and the scrotum, the hard rounded vas is felt as the most posterior structure (fig. 149). It is the first to slip from between the fingers as the cord is drawn forwards. The vas conveys the semen from the epididymis to the urethra. Its whipcord-like feel is due to enormously thick fibromuscular walls which contract to force the semen out. The vas is now to be found as it enters the external abdominal ring.

COURSE.—Three stages are recognised in the course of the vas deferens (fig. 148):

FIG. 147.—DIAGRAM OF THE SEMINIFEROUS TUBULES AND DUCTS OF THE TESTIS AND EPIDIDYMIS. (*Wilson.*)



1, 1. Tunica albuginea. 2, 2. Mediastinum testis. 3, 3. Seminiferous tubules. 4, 4. Vasa recta. 5. Rete testis. 6. Vasa efferentia, of which six only are represented in this diagram. 7. Coni vasculosi, constituting the globus major epididymis. 8. Body of the epididymis. 9. Globus minor epididymis. 10. Vas deferens. 11. Vas aberraus.

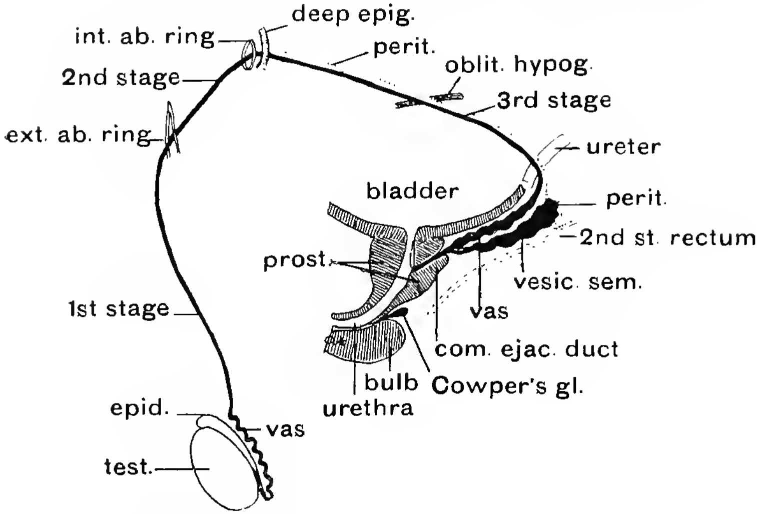
(1) SCROTAL, from its commencement in the lower end of the epididymis to the external abdominal ring. It is to be dissected out at the external abdominal ring and followed downwards into the scrotum. It becomes enlarged and tortuous as it joins the epididymis. The spermatic artery lies near it; the artery to the vas is on it; the plexus of spermatic veins lies

mostly in front of it (fig. 149). Much fibrous tissue—some of it representing the gubernaculum testis—surrounds it.

(2) INGUINAL, from the external to the internal abdominal ring within the inguinal canal. It lies on the floor of the canal.

(3) PELVIC, from the internal ring to its junction with the duct of the seminal vesicle to form the common ejaculatory duct. The ejaculatory duct opens in the floor of the prostatic urethra (fig. 148). At the commencement of this stage the vas will be seen turning round the origin of the deep epigastric artery, and crossing the external iliac vessels and brim of the pelvis beneath the peritoneum (fig. 139, p. 38). The latter part of its course will be seen in the dissection of the pelvis.

FIG. 148.—THE COURSE OF THE VAS DEFERENS. (*Diagrammatic.*)



On making a section, the vas will appear almost solid, so small is the lumen and so thick are the muscular coats.

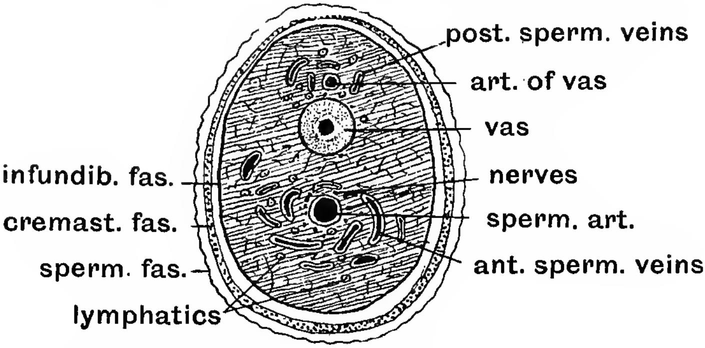
Spermatic Artery.—The origin of the spermatic arteries from the aorta below the renals will be seen later. The artery passes to the internal ring beneath the peritoneum of the iliac fossa. It reaches the posterior attached border of the testis, which it enters. Terminal twigs pass to the epididymis.

The **Spermatic Veins** form the pampiniform plexus within the covering of the cord (fig. 149). When enlarged they form a varicocele. They commence in the testicle and epididymis, and enter the abdomen by the inguinal canal and pass upwards beneath the peritoneum, where anastomoses with sub-peritoneal veins occur. On the right side the vein ends in the vena cava; on the left in the renal vein.

The nerves pass to the testis on the artery from the aortic plexus of the sympathetic. The lymphatic vessels accompany the veins to the lumbar glands.

Section of the Testicle.—The testicle is now to be removed from the scrotum. By pinning it out and dissecting it under water, the termination of the artery and commencement of the vas may be more closely examined.

Fig. 149.—Section of the spermatic cord. (*Diagrammatic.*)



The testicle is then to be opened by a section across its upper third. The section ends behind by passing through the epididymis. The following points are to be noted:

(1) The *tunica albuginea* (fig. 146). This is the stout, white, fibrous capsule of the testis. Externally it is coated by the visceral layer of the tunica vaginalis.

(2) The *mediastinum testis* (fig. 146), an inflection of the tunica albuginea into the testicle at its posterior border. Here the vessels enter and the vasa efferentia pass out. It contains the *rete testis* (fig. 147).

(3) The *septa*. Septa or partitions pass from the deep surface of the tunica albuginea to the mediastinum. They divide the testicle into compartments or loculi which contain the seminiferous tubules (fig. 147).

(4) The *tunica vasculosa* is the vascular membrane which

lines the inner surface of the tunica albuginea and septa. In it the spermatic artery is distributed.

(5) The *tubuli seminiferi.* By a needle, parts of these fine tubules may be picked up (fig. 147). They are coiled in masses within the loculi. Each tube is about two feet long.

COURSE OF THE SEMEN (fig. 147).—The semen is formed in the seminiferous tubules. From these it passes to the mediastinum by the straight vessels (vasa recta); in the mediastinum it passes through a network of tubes (rete testis); it passes by the *vasa efferentia* and *coni vasculosi* to the epididymis. The epididymis is made up mainly of a fine coiled tube, over twenty feet long. Through this tube the semen is conveyed to the vas. By the vas it is conveyed to the common ejaculatory duct which, in turn, carries the semen and the secretion of the vesiculæ seminales to the prostatic part of the urethra (fig. 148).

The Penis.—Only the free part of the penis is to be examined now; the root of the penis will be examined with the perineum.

THE PREPUCE.—A section should be made through the prepuce or hood of the glans. It will be seen to be a fold covered by skin externally and mucous membrane internally. The frenum binds it below to the glans. The artery of the prepuce is derived from the dorsal artery of the penis.

STRUCTURES ON THE DORSUM OF THE PENIS.—The skin is removed by an incision from the symphysis to the glans. It is thin and movable. The subcutaneous tissue is lax and contains no fat. When the skin is reflected the following structures should be found (fig. 150, B):

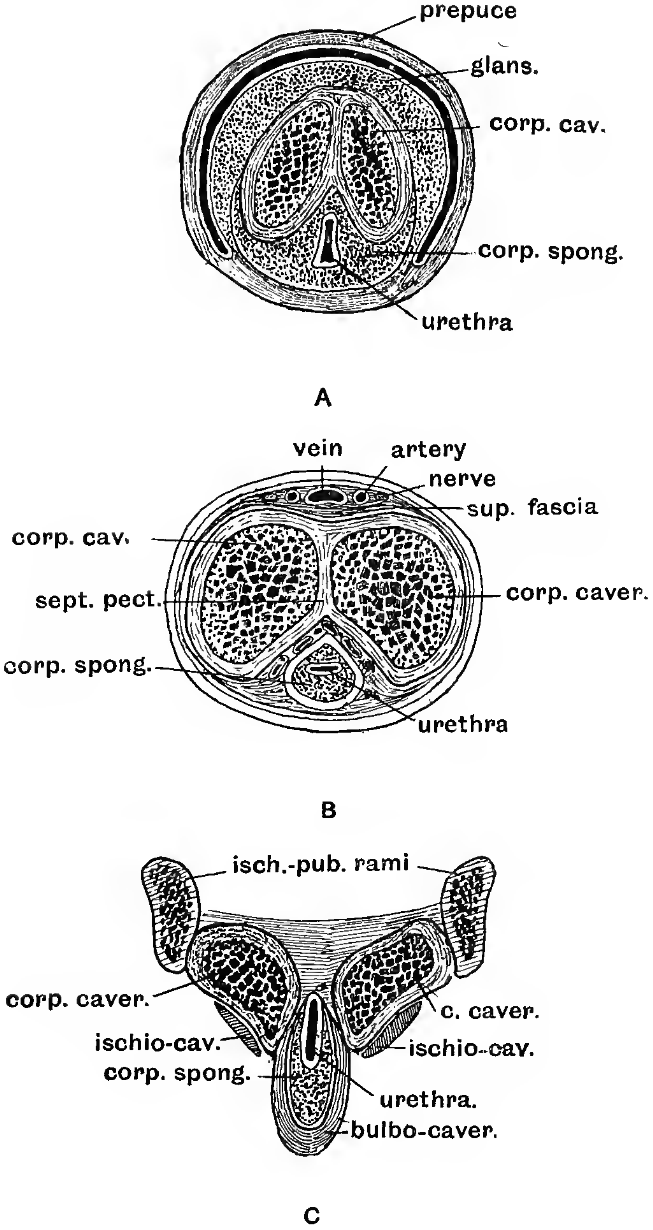
(1) The *dorsal vein of the penis.* It is median and single. When followed backwards it will be found to disappear beneath the symphysis pubis, where it perforates above the triangular ligament and ends in the prostatic plexus (fig. 190).

(2) On each side of it, the *dorsal artery* of the penis, the terminal branch of the internal pudic (fig. 127, p. 15).

(3) The two *dorsal nerves* of the penis, to the outer side of the arteries. These supply the skin and prepuce, and end in the glans. They are the terminal branches of the pudic nerve.

STRUCTURE OF THE PENIS.—In formalin-hardened bodies, the penis is firm and best studied by a series of sections. The first section should be made across the body of the penis,

Fig. 150.—Sections of the penis: A, of the glans; B, of the body of the penis; C, root of the penis.



midway between the glans and symphysis. The following structures are seen (fig. 150, B):

(1) The dorsal structures just mentioned; skin and superficial fascia.

(2) The two corpora cavernosa; their thick white fibrous capsules are united in the middle line, the *septum pectiniforme* marking the line of fusion. The cavernous blood-spaces of the corpora are seen now in section. The spaces when distended cause erection of the penis and are filled from the artery of the corpus cavernosum.

(3) The *corpus spongiosum*, lying in a groove between the cavernosa.

(4) The *urethra*, here a transverse slit in section, lies within the corpus spongiosum. The mucous membrane and submucous coat can be distinguished (fig. 150).

The spaces of the corpus spongiosum are filled from the artery to the bulb. The bulb is the posterior expanded end of the corpus spongiosum (fig. 128, 18, p. 17). The capsule or fibrous coat of the corpus spongiosum is thin.

The *Glans Penis*.—A section across the glans, just in front of the corona, shows (fig. 150, A):

(1) The anterior fibrous termination of the corpora cavernosa supporting the glans;

(2) The spongy tissue of the glans continuous with the corpus spongiosum. The glans may be regarded as the dilated anterior extremity of the corpus spongiosum. Its expanded posterior margin forms the *corona glandis*; the *cervix* of the penis is the constriction behind the corona. At the extremity of the glans the urethra opens by a vertical fissure—the *meatus urinarius externus*.

(3) The urethra, here a vertical slit. Beneath the glans the urethra shows a dilatation, the *fossa navicularis*. The external meatus is the narrowest point in the urethra.

Longitudinal sections of the penis are shown in figs. 128 and 211, p. 193.

When the urethra is split open, a tiny recess may be seen in the roof of the fossa navicularis, the *lacuna magna*. It may catch the point of a fine catheter.

Along both the floor and roof of the urethra will be seen the openings of the glands of Littré, minute tubular evaginations from the mucous membrane of the urethra.

A section of the penis made just in front of the symphysis pubis shows (fig. 150, c):

(1) The suspensory ligament of the penis (fig. 130), arising from the anterior aspect of the symphysis; the vessels and nerves seen in the section of the body;

(2) The corpora cavernosa, now apart;

(3) The enlarged posterior part of the corpus spongiosum or bulb. The urethra here lies in the upper segment of the spongy body and is triradiate or vertical in section.

DISSECTION VI

THE CONTENTS OF THE ABDOMINAL CAVITY

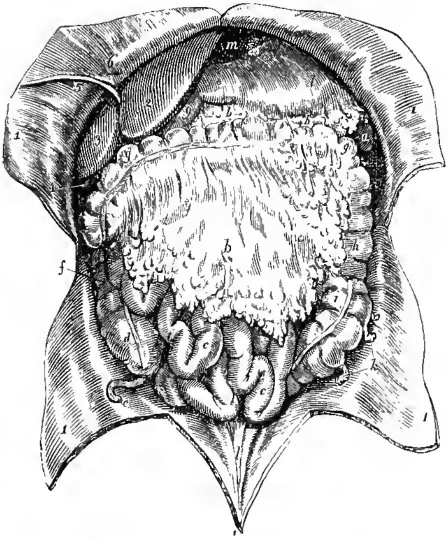
FALCIFORM LIGAMENT.—Up to the time of birth, the umbilical vein, which returned the arterial blood from the placenta to the child, entered the abdominal cavity at the umbilicus and passed to the under surface of the liver in a fold of peritoneum (fig. 172, p. 112). If, now, the cavity is opened by an incision from the ensiform cartilage to the umbilicus along the linea alba, this fold of peritoneum, the *falciform ligament*, will be seen stretching between the anterior abdominal wall and the liver. In its lower free border is a fibrous cord—the *ligamentum teres*—a remnant of the umbilical vein (fig. 151, 5).

REMOVAL OF THE ABDOMINAL PARIETES.—The muscles, fascia, and parietal peritoneum, which formed the belly-wall, are now to be removed in order that the contents may be freely seen and examined. The muscles must be detached at their origins and insertions; Poupart's ligament should be left to serve as a landmark. The student must remember, however, that in operating on the abdomen the cavity cannot be thus freely opened. He must know the arrangement and position of the organs and peritoneum so thoroughly that, through an incision only big enough to admit a few fingers, he will be able to tell the condition of parts. He will find, too, that the accurate diagnosis of abdominal diseases turns largely on his knowledge of the situation and relationships of viscera.

The Abdominal Cavity.—The abdominal cavity, which in all conditions is completely filled by its viscera, is bounded in front and at the sides by the anterior abdominal wall, and behind by the spine, psoas, iliacus and quadratus lumborum muscles (fig. 122, p. 7). Above it is bounded by the diaphragm, and below by the pelvic floor.

The cavity is divided by the brim of the pelvis into abdomen proper and pelvic cavity, but these two regions are continuous and lined by the same serous membrane.

Fig. 151.—View of abdominal contents on reflecting the parietes. (*Wilson.*)



1. Flaps of the abdominal parietes turned aside. 2. Liver, its left lobe. 3. Right lobe. 4. Fundus of the gall-bladder. 5. Round ligament of the liver, issuing from the cleft of the longitudinal fissure, and passing along the parietes of the abdomen to the umbilicus. 6 Part of the falciform ligament of the liver. 7. Stomach. 8. Its pyloric end. 9. Commencement of the duodenum. *a.* Lower extremity of spleen. *b*, *b*. Greater omentum. *c*, *c*. Small intestines. *d.* Cæcum. *e.* Vermiform appendix. *f.* Ascending colon. *g*, *g*. Transverse colon. *h.* Descending colon. *i.* Sigmoid flexure of colon. *k.* Appendices epiploicæ connected with the sigmoid flexure. *l.* Three ridges representing the cords of the urachus and hypogastric arteries ascending to the umbilicus. *m.* Diaphragm.

Abdominal Contents.—Upon opening the abdomen, the following contents are exposed (figs. 129, p. 20, and fig. 151):

(1) Just below the ensiform cartilage, and filling the subcostal or infrasternal triangle from the eighth cartilage on the left side to the ninth on the right, is seen a considerable portion of the liver.

(2) The fundus of the gall-bladder lies below the ninth right costal cartilage. Normally the lower margin of the liver appears just below the margin of the thorax on the right side.

(3) Below the liver a triangular area of the stomach comes into relation with the anterior abdominal wall. It lies above the level of a line drawn between the ninth right and left costal cartilages.

(4) Extending down from the stomach towards the pubis is the great omentum, which covers most of the large and small intestine.

(5) Usually some coils of the small intestine can be seen in the left iliac region.

(6) A portion of the large intestine is seen in each iliac fossa, viz. the cæcum in the right side and sigmoid colon in the left.

(7) The summit of a distended bladder also appears above the pubis.

On raising the great omentum the remaining part of the small intestine, together with the transverse colon, will be exposed.

(8) On turning aside the left costal margin and pulling the stomach to the right, a partial view of the spleen will be obtained, situated deeply in the left hypochondrium (fig. 151, *a*).

(9) On palpating the posterior abdominal wall behind the small intestines the outlines of the kidneys can be made out.

(10) On lifting upwards the great omentum, its base will be found attached to the transverse colon. The transverse colon emerges from beneath the liver on the right side, and, looping across the abdomen above the position of the umbilicus, it disappears beneath the left costal margin. It lies along the lower border of the stomach (fig. 129, p. 20).

Course of the Food.—The course taken by the food in the alimentary canal should be followed.

(1) The œsophagus will be found piercing the diaphragm behind the left lobe of the liver, and joining the cardiac end of the stomach.

(2) The food passes through the stomach, entering the duodenum at the pylorus (fig. 155, p. 71).

(3) The duodenum, in which the food is mixed with bile and pancreatic juice, is U-shaped and difficult for the beginner to trace (fig. 153, 25). It emerges to join the jejunum below the attachment of the mesentery of the transverse colon.

(4) The food then traverses the jejunum and ileum, the coiled part of the small gut.

(5) From the ileum it passes into the cæcum and ascending colon, situated in the right iliac and right lumbar regions.

(6) It crosses the abdomen in the transverse colon, and descends in the descending colon to the sigmoid colon in the left iliac region.

(7) Thence to the rectum and anus.

The Peritoneum.—Uses. The peritoneum, or abdominal serous membrane, lines the abdominal cavity and gives a partial or complete covering to the abdominal viscera. It serves as a bursa for the viscera of the abdomen. In digestion the stomach fills and empties; the bowels undergo peristaltic movements; with every breath there is a descent of the diaphragm and a movement downwards of the abdominal viscera. That these movements may take place with the least degree of friction possible, the cavity is lined and the viscera are covered by a smooth lubricated layer of peritoneum.

Further, the viscera have to be retained in position and supplied with blood-vessels. This purpose is served by reflections or folds of peritoneum which fix the viscera to the abdominal walls and convey vessels to them. Without such a binding membrane, the abdominal contents would be as movable as marbles in a schoolboy's pocket. It certainly appears a complex structure, but the student, if he will think the matter over, will see that it is evolved really out of a simple continuous saccular membrane.

One point he must never forget: that is, the great number of stomata, or microscopic lymphatic mouths, on its surface. Through these absorption takes place with great rapidity.

To understand thoroughly the arrangement of this membrane, a knowledge of the relations and development of the abdominal viscera is necessary, and for the present only its main disposition need be noticed. The special relations to the different viscera will be considered along with their general anatomy.

The **parietal** portion, where it lines the anterior abdominal wall and lumbar regions, has been considered (pages 9, 41).

The disposition of its **visceral** portion, as it covers the viscera, should now be traced. This is best done by following the serous membrane from viscus to viscus vertically and then transversely, when it will be seen to form certain folds which connect the viscera together. To these folds certain names are applied. Thus the term *mesentery* means a double fold of peritoneum attaching a portion of intestine to the posterior abdominal wall. An *omentum* is a fold connecting the stomach to another viscus. A *ligament* connects a viscus to the abdominal parietes without serving the vessel-carrying purpose of a mesentery.

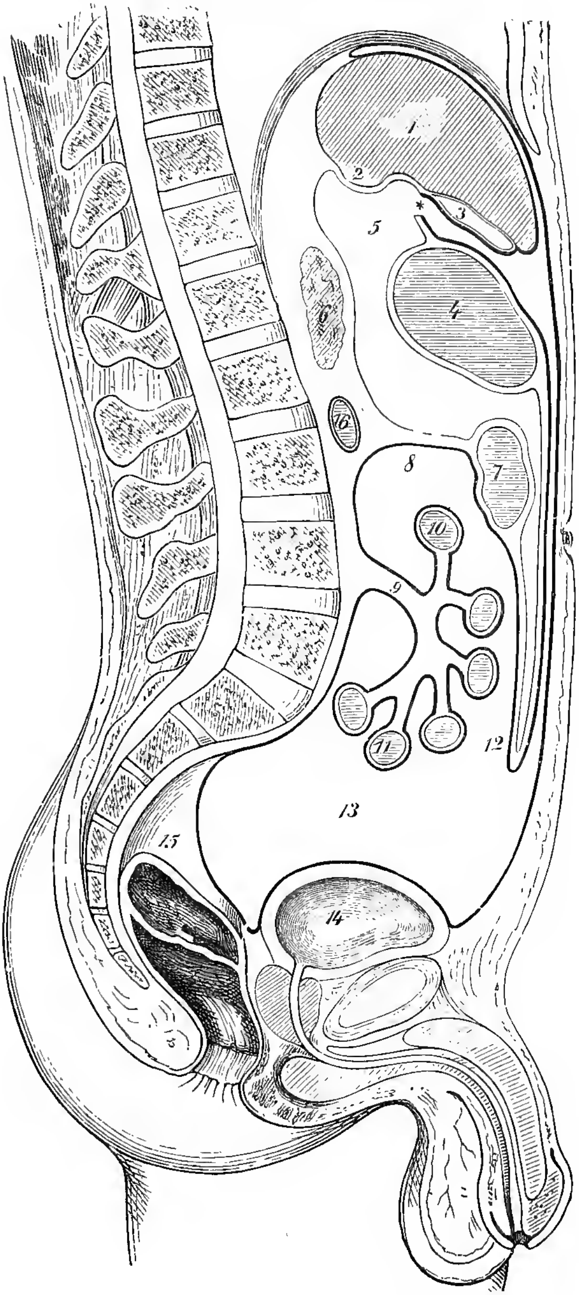
The Continuity of the Peritoneum.—1. *Traced in a Vertical Plane* (fig. 152).—Commence by tracing the peritoneum, which has been seen to cover the anterior abdominal wall, on to the under surface of the diaphragm, which it lines. At one point this is modified by the existence of the obliterated umbilical vein or round ligament of the liver (fig. 151, 5). Around this the peritoneum is reflected so as to form a vertical double layer between the diaphragm, abdominal wall, and upper surface of the liver. This is the *falciform or suspensory ligament* of the liver. Insinuate the two hands, one on each side of the falciform ligament, and notice that the peritoneum is reflected from the under surface of the diaphragm to the upper surface of the liver, forming here a reflected layer known as the upper layer of the coronary ligament of the liver (fig. 152). Further notice that by approximating the hands these reflected layers become continuous with the layers of the falciform ligament, and that by separating the hands and tracing the *coronary ligament* laterally it is found to be continuous with the *right* and *left lateral ligaments* of the liver, folds of peritoneum which fix the liver to the diaphragm (fig. 153, 4 and 17). Of these the left ligament is triangular in shape and much better marked than the right.

The peritoneum is next traced round the anterior margin of the liver to its under surface, covering also the fundus and under surface of the gall-bladder. On the under surface of the right lobe of the liver the peritoneum can be traced to its posterior border, but on the under surface of the left lobe, in the region of the transverse or portal fissure (fig. 156), it will be seen to be reflected from the liver to the adjacent border of the stomach and duodenum, on the anterior and posterior surfaces of the hepatic and portal vessels.

This reflected layer, which is seen by raising the anterior border of the liver and exposing the stomach, forms part of the *gastro-hepatic or lesser omentum.* The right border of this fold is free, and forms the anterior boundary of the *foramen of Winslow* (fig. 156, p. 74). This is the opening of communication with the lesser sac of the peritoneum, a great peritoneal diverticulum which lies behind the stomach (fig. 152, 5). By making a rent in the gastro-hepatic omentum, the interior of the lesser sac may be examined.

From the anterior surface of the stomach the membrane can be traced down, forming the anterior layer of the *gastro-colic* or *great omentum* (fig. 152, 12). This is a large fold of

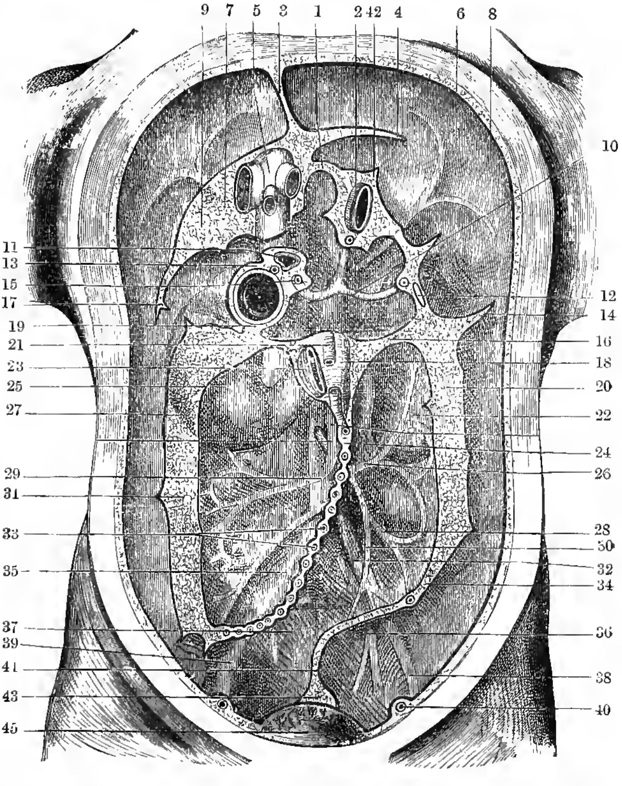
Fig. 152.—Showing the arrangement of peritoneum seen on making a vertical section of the abdomen. (*Braune.*)



Explanation in the text.

peritoneum attached to the greater curvature of the stomach and hanging down as an apron over the small intestines, its lower free border extending towards the pubis (fig. 151, B).

Fig. 153.—The reflection of the parietal peritoneum from the posterior wall to form the mesenteries, omenta, and ligaments. The stippled area is uncovered by peritoneum. (*Delépine, from Heath.*)



1. Upper end of the gastro-hepatic omentum. 2. Œsophagus. 3. Falciform ligament. 4. Left lateral ligament. 5. Vena cava inferior. 6. Diaphragm. 7. Phrenic artery. 8. Cut edge of peritoneum. 9. Hepatic area. 10. Splenic artery behind lesser sac. 11. Portal vein below foramen of Winslow. 12. Tail of pancreas in gastro-phrenic omentum. 13. Bile duct. 14. Costo-colic fold. 15. Hepatic artery. 16. Transverse mesocolon. 17. Right lateral ligament. 18. Aorta. 19. Pylorus. 20. Descending meso-colon. 21. Superior mesenteric artery. 22. Over left kidney. 23. Termination of duodenum. 24. Mesentery. 25. Second stage, duodenum. 26. Left colic artery. 27. Over right kidney. 28. Sigmoid artery. 29. Right colic artery. 30. Superior hæmorrhoidal artery. 31. Ascending meso-colon. 32. Left common iliac artery. 33. Vasa intestini tenuis. 34. Meso-sigmoid. 35. Mesentery. 36. Internal iliac artery. 37. Promontory of sacrum. 38. Right external iliac artery. 39. Left external iliac artery. 40. Left obliterated hypogastric artery. 41. Meso-sigmoid. 42. Gastro-phrenic ligament. 43. Meso-rectum. 45. Bladder.

It varies much in size, and in fat subjects it presents a considerable development of adipose tissue.

Occasionally it presents one or more perforations, which may engage a portion of intestine and thus give rise to obstruction. The great omentum consists of four layers (fig. 152), the two anterior layers enclosing the stomach (fig. 152, 4), while the two posterior layers, after enclosing the transverse colon (fig. 152, 7), are prolonged to the posterior abdominal wall as the *transverse meso-colon*. These four layers are distinct in the young subject, but in the adult they are blended together, excepting at the upper part of the omentum. Here the two gastric layers are separated from the two colic layers by the lesser sac. By perforating the gastric layers at the lower border or greater curvature of the stomach, the hand may be introduced behind the stomach and within the lesser sac. Further, the finger may be protruded at the foramen of Winslow, the mouth of the lesser sac.

Having turned up the great omentum towards the ribs, notice how its two posterior layers enclose the transverse colon and reach the posterior abdominal wall, forming the transverse meso-colon (fig. 153, 16). On the posterior abdominal wall the lower of the two layers of the transverse meso-colon (fig. 152, 8) descends and covers the anterior surface of the third part of the duodenum (fig. 153, 25).

Below the attachment of the transverse meso-colon the coils of bowel will be seen, and when picked up they will be found bound to the posterior wall by a continuous sheet, the *mesentery* (figs. 152, 9, 10, 11; 153, and 118). The mesentery is composed of two layers of peritoneum, right and left, which enclose the bowel and convey blood-vessels to it (fig. 153, 24, 33). The peritoneum, descending over the third part of the duodenum from the meso-colon, becomes continuous with the mesentery and with the peritoneum on the posterior abdominal wall on each side of the attachment of the mesentery.

The student must find the end of the duodenum and the commencement of the free bowel (fig. 153, 23). He should then follow the small gut along, bunching it in his hand as he goes. There are over twenty feet of it. The termination will be found down in the right iliac fossa at the cæcum (fig. 153). When he has thus gathered up and put in order the small gut he will see that the mesentery is a fan-shaped structure having a limited line of attachment, extending obliquely on the posterior abdominal wall from the left side of the second lumbar vertebra to the right iliac fossa, a distance of from five to six inches (fig. 153), while its intestinal border corresponds in length to the jejunum and ileum, about twenty feet or more. The length of the mesentery from the bowel to its attachment on the posterior abdominal wall is about eight inches at its longest parts. Between the layers of the mesentery are the mesenteric vessels, nerves, lacteal vessels and glands. From the mesentery the peritoneum can be traced on the posterior abdominal wall (fig. 152), over the aorta and sacral promontory, into the pelvis, where its relation to the pelvic viscera will be subsequently considered. From the pelvis it has already been seen to emerge on the urachus and obliterated hypogastric arteries, and cover the anterior abdominal wall.

The student will thus see that the peritoneum is a continuous membrane when traced in the middle line. He has traced it from the umbilicus to the diaphragm, liver, stomach, bowel, pelvis, bladder, and on the anterior abdominal wall back to the umbilicus again (fig. 152).

2. *Horizontal Tracing of Peritoneum* (fig. 118, p. 3).—The student is now to trace the continuity of the peritoneum in a horizontal plane, beginning at the umbilicus and passing round the abdominal wall back to the umbilicus again. The great omentum is turned upwards on the ribs. The tracing below the level of the transverse meso-colon is simple. The peritoneum, as it passes across the posterior abdominal wall, covers the lateral and anterior surfaces of the ascending colon and descending colon, and attaches them to the lumbar regions by a mesentery or meso-colon. In front of the spine it is reflected to enclose the small bowel and form *the mesentery.* It is more profitable for the student to study the peritoneum in connection with each organ than to spend more time now on a general survey of this rather complex structure.

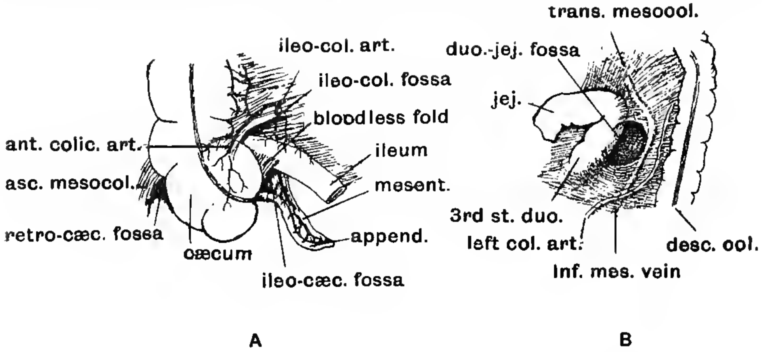
Peritoneal Pouches or Fossæ.—A number of small peritoneal fossæ or shallow diverticula of the peritoneum occur in connection with some of the abdominal viscera. They are important because they may become enlarged and form a sac into which the bowel becomes herniated. They are not constant; their size and shape are variable. These must now be found and examined.

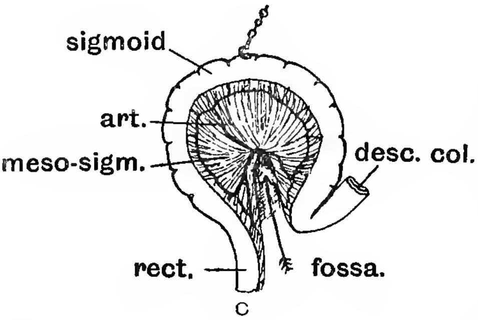
1. *Duodeno-jejunal Fossa* (fig. 154, B).—It is situated on the posterior abdominal wall, at the left side of the commencing jejunum. A small oblique fold of peritoneum will be found passing upwards and to the left, ending over the termination

of the duodenum. The fold may contain the inferior mesenteric vein. The duodeno-jejunal fossa lies between the emerging bowel and the oblique fold. It usually is deep enough to take the tip of the forefinger.

2. *Ileo-colic Fossa.* It is situated in the angle between the ileum and ascending colon (fig. 154, A). The anterior cæcal artery causes a peritoneal fold which bounds the fossa above.

Fig. 154.—Diagrams of peritoneal fossæ: a, in the region of the cæcum; b, in the region of the duodenum; c, in the region of the sigmoid colon.





3. *Ileo-cæcal Fossa.* This pocket lies in the angle between the ileum and cæcum (fig. 154, A). Its mouth is directed downwards. The *bloodless fold* (Treves), passing from the termination of the ileum to the cæcum, bounds the fossa in front; the mesentery of the appendix bounds it behind.

4. *Retro-* or *Sub-cæcal Fossa.* When the cæcum is raised this fossa is seen behind it. Its mouth is directed downwards.

5. *Intersigmoid Fossa* (fig. 154, C). The sigmoid colon lies in the left iliac fossa, attached by the meso-sigmoid (fig. 153, 34). When lifted upwards, a pouch or recess is frequently seen beneath the meso-sigmoid, between it and the posterior abdominal wall, to which the name *intersigmoid* has been given.

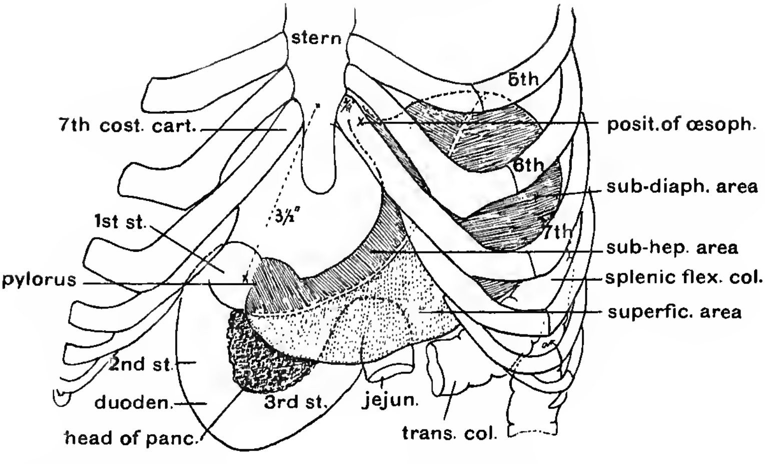
Its mouth is directed downwards and to the left. Other peritoneal fossæ have already been described in the inguinal region (fig. 143, p. 44).

THE STOMACH

The stomach lies in the epigastric and left hypochondriac regions, and presents two openings (œsophageal and pyloric), two surfaces (anterior and posterior), two curvatures (greater and lesser), and a fundus.

The greater part of the stomach lies in the left hypochondriac region, beneath the ribs and diaphragm (fig. 155). Only a small triangular area below the liver is really superficial and easily accessible for examination or operation.

Fig. 155.—Diagram showing the position and anterior relationships of the stomach.



The *superficial area* lies in the sub-costal angle behind the abdominal wall, and includes the pyloric end and a small part of the cardiac end. This area is marked out by a triangle drawn between the three following points (fig. 155): (1) the convexity of the ninth right costal cartilage; (2) the convexity of the ninth left costal cartilage; (3) the tip of the eighth left costal cartilage.

The *œsophageal or cardiac orifice* will be seen deeply situated when the left lobe of the liver is raised, receiving the termination of the gullet (fig. 158, 6). It lies a little to the left of the middle line, behind a point on the seventh left costal cartilage, $\frac{3}{4}$ inch from the sternum, and on a level with the tenth dorsal vertebra. About half an inch of the œsophagus is seen below the diaphragm, placed obliquely. To the left side of the cardiac orifice is a slight fold of peritoneum, the gastro-phrenic ligament, which connects the stomach to the diaphragm (fig. 153, 42).

The *pyloric orifice* is marked by its sphincter, a distinct thickening of the circular muscular coat, which can be felt at the junction of the stomach and duodenum (fig. 167, p. 101). It lies about an inch to the right of the middle line, and between three and four inches below the sternal ends of the seventh costal cartilages. It is impossible to give exact figures, for the position varies, especially in diseased conditions. The pylorus is partly hid by the quadrate lobe of the liver.

It will thus be seen that the position of the stomach is nearly vertical; the line connecting its orifices is only three or four inches long, and crosses the linea alba at a very sharp angle.

The *anterior surface* of the stomach is in relation to liver, diaphragm, and anterior abdominal wall (see fig. 155).

The *posterior surface* is covered by the anterior wall of the lesser sac of the peritoneum. The sac separates it from the posterior abdominal wall, abdominal aorta, cœliac axis, pancreas, left kidney, left supra-renal and spleen (figs. 152, 153).

The *lesser curvature*, which extends from the cardiac to the pyloric orifices, has the lesser omentum attached to it, and between the layers of this are the coronary and pyloric vessels (fig. 156). It lies entirely beneath the liver.

The *greater curvature* is for the most part in contact with the transverse colon, and has the great omentum attached to it. It is three times as long as the lesser curvature. The right and left gastro-epiploic vessels are distributed on it.

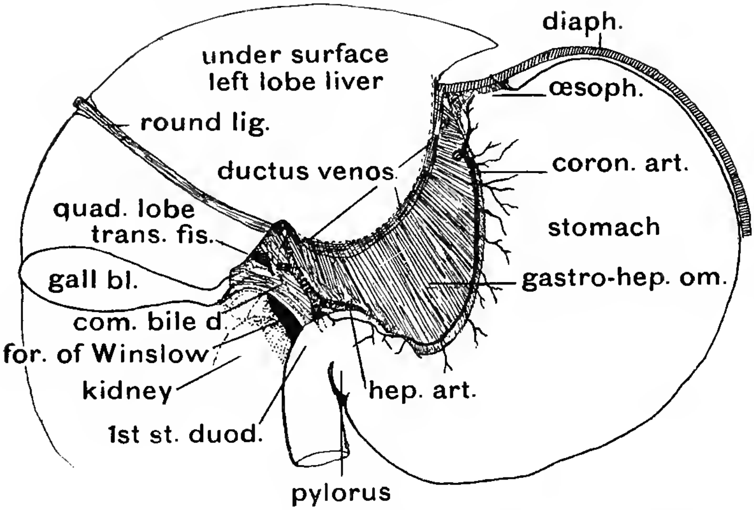
The *fundus* forms a large cul-de-sac to the left of the œsophageal orifice and is part of the cardiac division of the stomach. It occupies the left dome of the diaphragm. The apex of the heart lies over it, only the diaphragm and pericardium intervening.

DIVISIONS.—Frequently a constriction, more or less marked, indicates the division of the stomach into *cardiac* and *pyloric* parts. The pyloric part is commonly tubular in shape, but in other conditions shows a marked dilatation, the *antrum pylori*. The cardiac part forms two thirds of the entire stomach.

Fixation of the Stomach.—The stomach is kept in position by: (1) The gastro-hepatic omentum; (2) the gastro-phrenic ligament and œsophagus; (3) the duodenum; (4) the pressure of surrounding organs and of the abdominal walls.

1. *Gastro-hepatic Omentum.* When the liver and stomach are separated as far as possible a good view of this peritoneal ligament or fold will be obtained (fig. 156). *Below*, it is attached to the lesser curvature of the stomach from the termination of the œsophagus to some distance along the first stage of the duodenum. *Above*, it is attached to the following points, commencing at the œsophageal end: (1) to the diaphragm; (2) to the posterior part of the longitudinal fissure of the liver—the fissure of the ductus venosus (see fig. 156); (3) to the transverse fissure of the liver.

Fig. 156.—Diagram of the gastro-hepatic omentum, and foramen of Winslow.



Its left end terminates in an angle at the œsophagus; its right end forms a free edge between the duodenum and transverse fissure of the liver. The free edge forms the anterior boundary of the foramen of Winslow. The omentum consists of two layers of peritoneum. Between them, in front of the foramen of Winslow, the hepatic artery and portal vein pass up to the liver and the bile duct descends to open in the duodenum.

It will thus be seen that the stomach is bound closely to the liver and must follow in its displacements. The omentum is completely covered by the liver in the natural position of parts.

2. The *gastro-phrenic ligament* has been already examined. When the stomach is afterwards removed a small area behind the cardiac orifice will be found uncovered by peritoneum, and bound to the diaphragm by loose connective tissue (fig. 153, 42). The œsophagus is loosely bound to its orifice in the diaphragm.

3. As the stomach is continuous with the duodenum, a fixed structure, it obtains a certain amount of support from it.

Relationship of the Stomach to Peritoneum.—The parts of the peritoneum specially connected with the stomach are :—(1) Gastro-hepatic omentum, just described; (2) gastro-phrenic ligament; (3) gastro-splenic omentum; (4) great omentum; (5) the lesser sac.

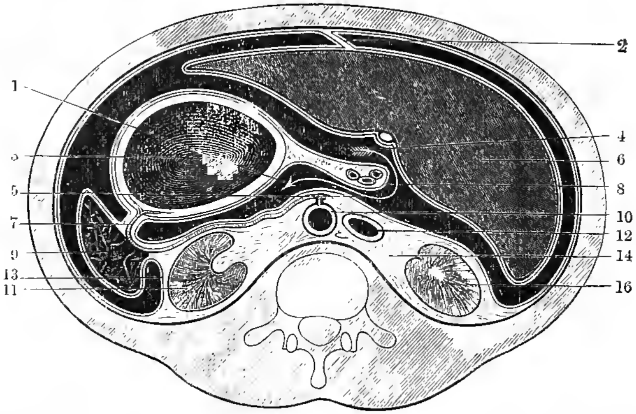
Gastro-splenic Omentum.—This omentum, composed of two layers, binds the greater curvature of the stomach at the fundus to the hilum of the spleen (fig. 157, 7). When the stomach is pulled forwards, the omentum will be seen. Above it is continuous with the gastro-phrenic ligament; below it is continued into the anterior layer of the great omentum. In it the vasa brevia and left gastro-epiploic arteries (fig. 157, 7), branches of the splenic, reach the stomach. This omentum also helps to retain the stomach in position. In the natural position of parts it lies behind the stomach.

Great Omentum.—The two gastric layers of the great omentum are attached to the greater curvature of the stomach (fig. 152, 12). The right gastro-epiploic artery runs along its attachment (fig. 158, 23). On the left side it is attached to the hilum of the spleen, and is continuous with the gastro-splenic omentum; on the right it tapers off at the pylorus and becomes continuous with the layers of the posterior wall of the lesser sac.

The Lesser Sac.—The lesser sac is a diverticulum of the peritoneum in which the posterior wall of the stomach rests, and which acts as a bursa for the stomach (figs. 152, 5, 156, and 157, 1).

The Foramen of Winslow is the mouth of the lesser sac (fig. 156). The gall-bladder serves as a guide to it. The neck of the bladder and its duct, the cystic, are contained in the free edge of the gastro-hepatic omentum which bounds the foramen in front. When the finger is inserted within the foramen its boundaries are seen to be formed thus (figs. 156 and 157, see arrow): *Above*, caudate lobe of the liver; *behind*, inferior vena cava; *below*, first stage of duodenum; *in front*, gastro-hepatic omentum, containing the portal vein, bile ducts, and hepatic artery (fig. 166, p. 94).

Fig. 157.—The relationship of the stomach to peritoneum as seen in transverse section. (*Anderson.*)

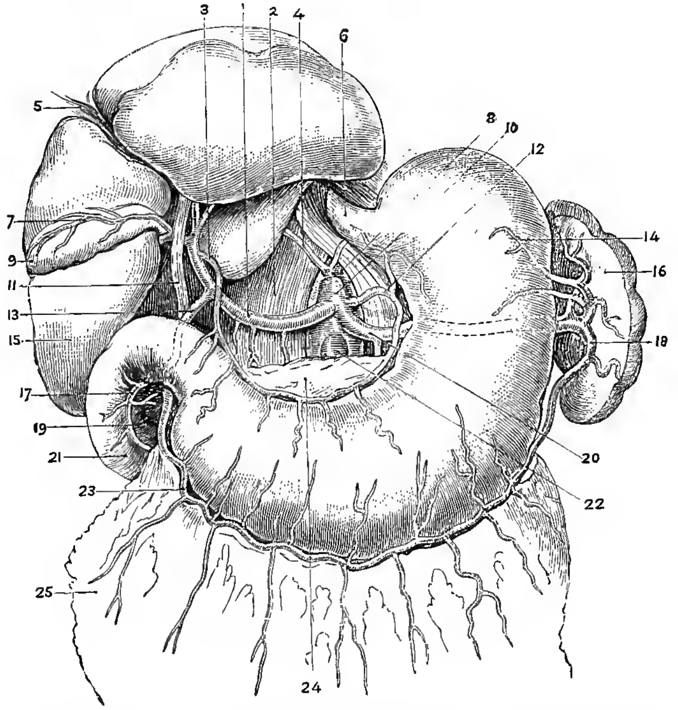


1. Point of arrow in lesser sac. 2. Falciform ligament. 3. Cardiac end of stomach. 4. Feather of arrow in greater sac. 5. Foramen of Winslow. 6. Liver. 7. Gastric vasa brevia of splenic artery in gastro-splenic omentum. 8. Gastro-hepatic omentum. 9. Spleen. 10. Aorta. 11. Left kidney. 12. Vena cava. 13. Posterior reflection of lieno-renal ligament. 14. Sub-peritoneal tissue. 16. Right kidney.

The *anterior wall* of the lesser sac is formed thus: (1) The gastro-hepatic omentum; (2) peritoneum covering posterior wall of stomach; (3) gastric layers of great omentum; (4) gastro-splenic omentum (figs. 152 and 157).

The *posterior wall* of the lesser sac can be examined by raising the greater curvature of the stomach and detaching the gastric layers of the great omentum from it. The peritoneum will be seen to form (fig. 153): (1) A recess which separates the Spigelian lobe of the liver from the right crus of the diaphragm, the *Spigelian recess* (below 1 in fig. 153); (2) a covering for the anterior surface of the pancreas (fig. 152, 6) and part of the diaphragm (fig. 153) ; (3) for the cœliac artery and its branches at the upper border of the pancreas (fig. 158) ; (4) for the left supra-renal body and left kidney ; (5) the lieno-renal ligament, a fold of peritoneum joining the spleen and kidney (fig. 157, in front of 13) ; (6) the upper layer of the transverse meso-colon (fig. 152, 8). All these structures lie behind the stomach.

FIG. 158.—DISTRIBUTION OF THE CŒLIAC AXIS. (*After Henle.*)



1. Hepatic artery. 2. Right crus of diaphragm. 3. Pyloric artery. 4. Right phrenic artery. 5. Round ligament of liver. 6. Œsophagus. 7. Cystic artery. 8. Abdominal aorta. 9. Gall-bladder. 10. Cœliac axis. 11. Ductus communis choledochus. 12. Gastric or coronary artery. 13. Gastro-duodenal artery. 14. Vasa brevia of splenic artery. 15. Liver. 16. Spleen. 17. Pancreatico-duodenalis (superior). 18. Gastro-epiploica sinistra. 19. Head of pancreas. 20. Splenic artery. 21. Duodenum. 22. Superior mesenteric artery. 23. Gastro-epiploica dextra. 24. Pancreas (drawn down). 25. Great omentum.

If a gastric ulcer perforates on the posterior wall, the contents of the stomach pass into the lesser sac. From the lesser sac they can pass into the general peritoneal cavity by only one route, the foramen of Winslow.

Blood Supply.—The following arteries, to be fully dissected at a later stage, are distributed from the cœliac axis to the stomach (fig. 158):

(1) Coronary artery, to the œsophagus and cardiac end. It passes from left to right on the lesser curvature.

(2) Pyloric branch of hepatic, to pylorus on the lesser curvature, joining the coronary.

(3) Vasa brevia. They reach the greater curvature in the gastro-splenic omentum, and are branches of the splenic (figs. 157 and 158).

(4) The left gastro-epiploic artery rises from the splenic and passes along the greater curvature.

(5) The right gastro-epiploic is a derivative of the hepatic. It is distributed on the greater curvature, passing from right to left.

The stomach is richly supplied with blood. There is a free anastomosis in the gastric wall between its arteries.

VEINS accompany the arteries on the stomach. All the venous blood, with any products absorbed from the stomach, passes to the liver by the portal vein. The coronary and pyloric veins join the portal trunk; the right gastro-epiploic vein ends in the superior mesenteric (fig. 166, p. 94), the left in the splenic vein.

NERVES.—The two vagi terminate on the stomach. They should be looked for now as they enter on the œsophagus, the left to terminate on the anterior surface of the stomach, the right on the posterior surface (see fig. 234, p. 235). This distribution will be understood when it is remembered that the greater curvature is the dorsal border, and the anterior and posterior surface left and right, in the early human fœtus.

Besides the vagi, the stomach receives numerous nerves on its arteries from the solar plexus. These come from the lower dorsal segments of the spinal cord by the great splanchnic nerves.

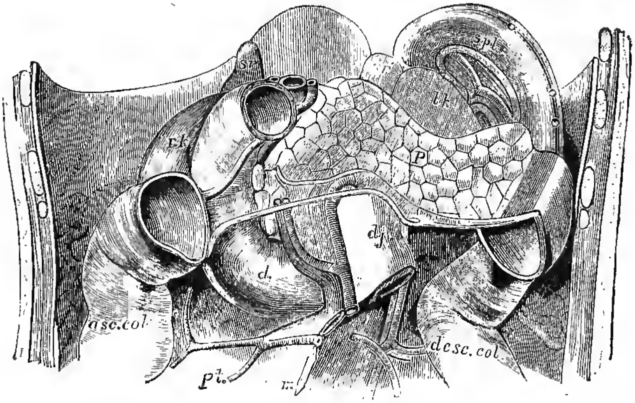
LYMPHATIC VESSELS AND GLANDS.— The lymphatic vessels pass mostly to a group of glands along the lesser curvature. There are some glands situated along the greater curvature and behind the pylorus. The gastric lymph passes to the cœliac group of glands, at the upper border of the pancreas, behind the lesser sac, and from there to the thoracic duct. The student should remember that cancer of the stomach spreads along the lymph channels.

SMALL INTESTINE

The small intestine is about 20 feet long and extends from the pylorus to the ileo-cæcal valve, the opening into the great intestine. Its length varies widely with the state of contraction of its muscular coats and with the individual. It has been artificially divided into three parts:

1. **Duodenum,** a fixed part, bound to the posterior abdominal wall by peritoneum (fig. 159).
2. **Jejunum,** the upper two fifths of the free bowel.
3. **Ileum,** the lower three fifths of the free bowel.

FIG. 159.—THE POSITION AND RELATIONSHIPS OF THE DUODENUM AND PANCREAS. (*His.*)



Over the divided upper end of the duodenum are seen the portal vein, hepatic artery, and bile-duct. The root of the transverse mesocolon extends across the pancreas between the cut extremities of the colon.

sr. Right suprarenal capsule. *sr'* Left suprarenal capsule. *rk.* Right kidney. *spl.* Spleen. *asc. col.* Ascending colon. *lk.* Left kidney. *pl.* Colica dextra. *p.* Pancreas. *m.* Mesentery (cut). *dj.* Termination of duodenum. *d.* Duodenum. *desc. col.* Descending colon.

In this part of the alimentary tract digestion and absorption proceed most actively. The student should note: (1) the manner in which the bowel is fixed by peritoneum; (2) its blood and lymphatic vessels; (3) its nerves; (4) the structure of its walls.

The **Duodenum,** so named from its length (twelve finger-breadths, about ten inches), is for the most part fixed in position, and, although having a partial peritoneal investment, is destitute of a mesentery. The lumen of the duodenum is greater than that of the remainder of the small intestine.

It almost completely encircles the head of the pancreas (fig. 159). It begins at the pylorus and ends beneath and behind the pyloric end of the stomach, only the neck of the pancreas separating its pyloric and jejunal extremities (fig. 169, p. 106). It is firmly bound to the pancreas, and both are bound by connective tissue to the posterior wall of the abdomen. It is the most fixed part of the alimentary tract, excepting the anal canal and œsophagus.

STAGES.—The duodenum is divided into three parts, each having different relations. The *first stage* extends from the pylorus to the neck of the gall-bladder; it is almost completely covered by a prolongation of the layers of peritoneum which invest the stomach. It passes backwards and to the right beneath the quadrate lobe of the liver and neck of the gall-bladder, then turns downwards to join the second stage. Behind it and to its left pass down the bile duct, portal vein, and gastro-duodenal artery (fig. 169, p. 106). During distension of the stomach this portion of the duodenum becomes covered in front by the pyloric end of the stomach. The junction between the first and second portions of the duodenum impresses the liver near the neck of the gall-bladder (impressio duodenalis) (fig. 171, 15, p. 111).

The *second stage* descends from the neck of the gall-bladder to the right side of the third, or sometimes the fourth, lumbar vertebra; it lies in front of the inner part of the right kidney and its hilum, which contains the ureter and renal vessels. The second stage is covered only in front by peritoneum. The anterior surface is divided into upper and lower parts by the attachment of the transverse meso-colon (figs. 153, p. 67, and fig. 159). Thus part of the anterior surface of the second stage appears above the transverse meso-colon and is covered by the *supra-colic* layer of peritoneum; part appears below the transverse meso-colon and is covered in front by the *infra-colic* layer of peritoneum. Its left aspect is grasped by the head of the pancreas. The post-duodenal stage of the common bile duct descends between it and the head of the pancreas (fig. 169, p. 106). The common bile duct opens on its inner aspect, a little way above the bend formed between this stage and the next (fig. 169). Into this bend—the duodenal syphon—the bile and pancreatic juices are poured; it forms a receptaculum for mixing the acid chyme and pancreatic juice.

The *third stage* of the duodenum passes upwards and to the left, beneath the *infra-colic* layer of peritoneum, and terminates by turning forwards to join the jejunum at the *duodeno-jejunal flexure* (fig. 159, *dj*). Only its anterior surface is covered by peritoneum. The superior mesenteric vessels cross in front of it, emerging between it and the neck of the pancreas. Behind it lie (1) the lower end of the right kidney, (2) the ureter, (3) inferior vena cava, (4) right crus of the diaphragm, (5) aorta and right renal vessels. It terminates on the left side of the upper border of the second lumbar vertebra.

Muscle of Treitz.—This is a slight fibro-muscular band which will be found fixing the duodeno-jejunal flexure to the left crus of the diaphragm. It lies beneath the peritoneum.

Jejunum and Ileum.—The jejunum and ileum, as has already been seen, are completely covered by peritoneum and suspended from the posterior abdominal wall by the mesentery. In this tract of the alimentary canal assimilation and absorption of food proceed rapidly. The superior mesenteric artery breaks up within the mesentery into hundreds of minute branches, which enter at the attached border and ultimately end in the great submucous plexus of vessels. The venules emerge at the attached border and join to form the superior mesenteric vein, which conveys the blood to the portal vein and thus to the liver. The lymphatics—chyle vessels—ascend in the mesentery through groups of lymphatic glands (mesenteric) to reach the thoracic duct, conveying certain products of digestion. Numerous nerves reach the bowel from the sympathetic plexuses. The right vagus also sends some twigs, at least to the upper part of the gut. At the attached border, where these vessels and nerves enter, there is a slight uncovered space on the bowel, between the two layers of the mesentery. This will be seen if an incision is made through the mesentery at its attachment. It gives rise to some surgical difficulty in uniting the divided ends of gut.

The *jejunum* is the upper two fifths, the ileum the lower three fifths of the small gut, but no sharp line separates them. The characters of the jejunum are those due to more active absorption. They are: (1) Its diameter is greater and its coats thicker; (2) its mucous membrane is increased by being thrown into numerous and prominent transverse folds —*valvulæ conniventes.*

The *ileum* is characterised by: (1) Its narrower diameter and thinner coats; (2) the valvulæ conniventes are small or absent; (3) the solitary follicles, minute masses of lymphoid tissue, are aggregated in oval fields—*Peyer's patches.* These are situated opposite the attached border of the gut.

The commencement of the jejunum and termination of the ileum are the two most fixed parts of this tract of the gut. The ileum terminates at the ileo-cæcal valve (fig. 161). Here the ileum may become invaginated within the wider ascending colon and give rise to a form of strangulation (intussusception).

Meckel's Diverticulum.—In two bodies in every hundred the student may expect to find this remnant of the neck of the embryonic yolk sac—the vitelline duct. It occurs on the free border of the ileum, two to four feet above the ileo-cæcal valve. It varies from the size of a thimble to that of a small sausage.

The Large Intestine.—The large intestine is about five or six feet long, and extends from the right iliac fossa to the anus. It is about twice the width of the small intestine, and becomes somewhat narrower as traced onwards until it reaches the dilated ampullary portion of the rectum.

The large intestine (excluding the rectum) may be said to differ from the small intestine in the following particulars as seen on their external surfaces:

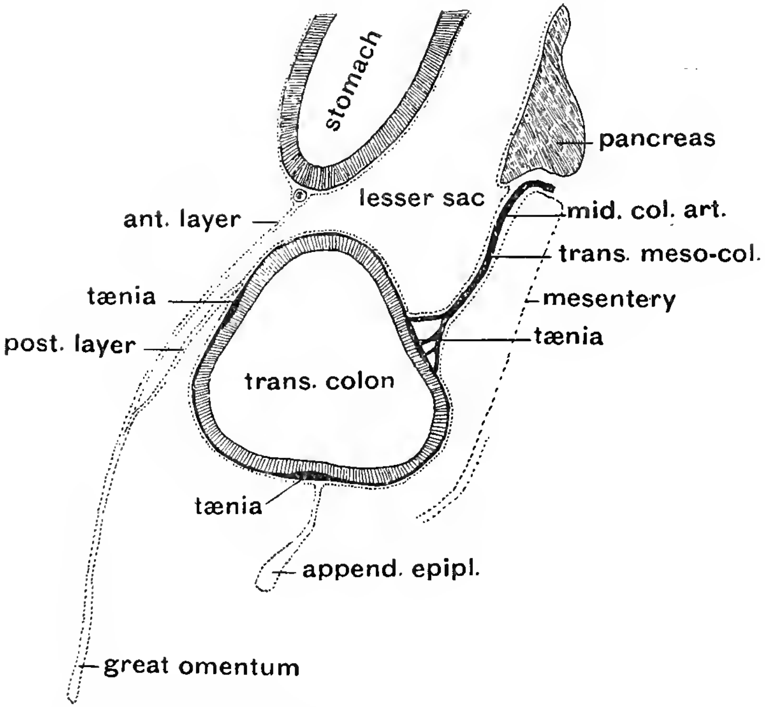
(1) The large intestine is sacculated, thus differing from the even surface of the small intestine. The sacculations affect the whole thickness of the gut. The mucous membrane shows ridges which correspond to the constrictions on the surface.

(2) The longitudinal muscular fibres of the large intestine are mainly arranged in three bands or *tæniæ*, instead of being uniformly spread out in a continuous layer as in the small intestine (fig. 160). The three tæniæ commence on the cæcum at the attachment of the appendix. Their position on the transverse colon is most marked. One lies at the attachment of the omentum (omental); one in the attachment of the transverse meso-colon (mesenteric); one on the anterior surface—to which the appendices epiploicæ are attached (epiploic). The tæniæ form a continuous covering of longitudinal muscular fibres on the appendix and rectum.

(3) Small processes of peritoneum containing fat, the *appendices epiploicæ*, are found on the large intestine.

(4) Internally the large intestine differs from the small intestine by the absence of villi, valvulæ conniventes, and Peyer's patches. The lymphoid tissue is arranged as numerous solitary follicles.

Fig. 160.—A section of the transverse colon, showing its structure and relationship.



The large intestine is divided into the three following parts:

I. Cæcum and Appendix. II. Colon.
III. Rectum.

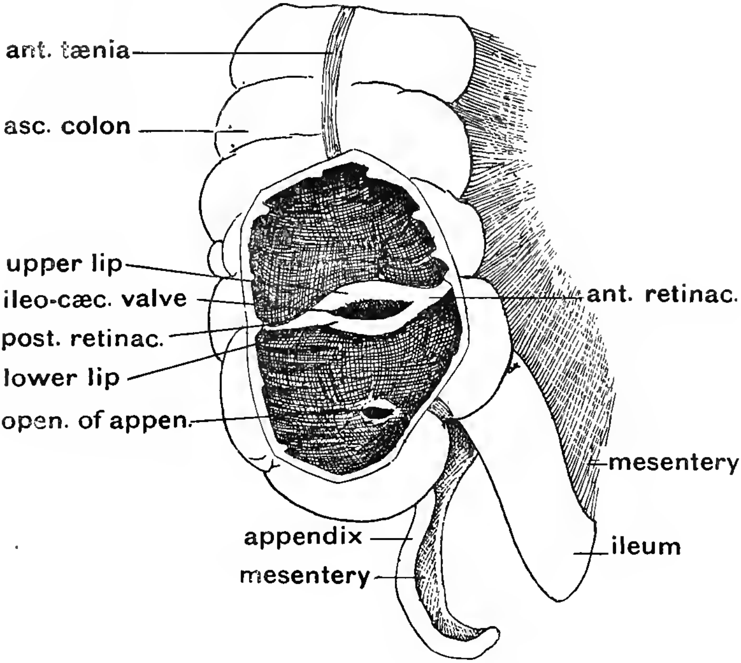
The colon is subdivided, according to the direction, shape, and positions of its various parts, into:

1. Ascending colon.
2. Hepatic flexure.
3. Transverse colon.
4. Splenic flexure.
5. Descending colon.
6. Sigmoid colon.

Appendix Vermiformis.—In recent years this small part of the gut has assumed great surgical importance. The student must pay close attention to its structure, position, and relationships.

Its length varies from four to seven inches; its diameter is little more than that of an ordinary lead pencil. It springs from the inner and posterior aspect of the cæcum below the opening of the ileum at the ileo-cæcal valve (fig. 161). It lies behind the cæcum in the right iliac fossa. The position on the surface of the body is indicated by a point an inch below the mid-point of a line drawn between the anterior superior spine and umbilicus. The point indicates its cæcal end. The apex usually passes towards the spleen under the termination of the ileum, but it may be found behind the ascending colon or hanging within the pelvis.

Fig. 161.—The cæcum, appendix, and ileo-cæcal valve.



It is completely covered by peritoneum and supported by a mesentery (fig. 154, p. 70, and fig. 161), a falciform fold from the mesentery of the gut, which contains the artery of the appendix. The mesentery separates the ileo-cæcal peritoneal fossa in front from the sub-cæcal fossa behind.

A section across the appendix shows how small its lumen is. The submucous lymphoid tissue almost obliterates it. Lymphatics begin in the lymph spaces beneath the solitary follicles, pierce the muscular coat, and pass into the lymphatic system of the mesentery.

The **Cæcum**, or **Caput Cæcum Coli**, is the blind pouch of large intestine below the ileo-cæcal orifice. It lies in the right iliac fossa, over the iliac fascia and muscle, and above the outer half of Poupart's ligament (fig. 129, p. 20). The palm of the hand covers it when placed on the abdominal wall internal to the anterior superior spine, and above the outer half of Poupart's ligament. It is completely covered by peritoneum. Behind it a sub-cæcal pouch of peritoneum may be found (fig. 154, p. 70). The cæcum, although not provided with a mesentery, is kept firmly in position by its continuity with the ascending colon and ileum. These are bound to the posterior abdominal wall by the ascending meso-colon and lower end of the mesentery.

FORMS.—The anterior tænia ascends in front of it. Its fundus, or blind end, is usually bellied out in two wide sacculi on each side of the anterior tænia. In some cases the outer sacculus is very large, the inner small, or *vice versa*. In the newly born child, the fundus of the cæcum tapers into the appendix. This fœtal form may persist in the adult.

The interior of the cæcum and ileo-cæcal valve will be examined when the intestinal contents have been washed out.

The **Ascending Colon**, which has been already exposed in the lumbar region (figs. 117 and 118), extends from the right iliac to the right hypochondriac region, where it ends in the *hepatic flexure* (fig. 129, p. 20). This lies in relation to the colic impression on the under surface of the right lobe of the liver (fig. 172, p. 112). The ascending colon, as it passes upwards through the lumbar region, lies directly on the fascia of the quadratus lumborum and right kidney, and to the outer side of the psoas muscle. The posterior surface of the gut is usually devoid of peritoneum, the extent of the uncovered surface being greatest when the gut is distended. In the upper part of the right hypochondriac region, a transverse peritoneal fold passes in front of the right kidney from the hepatic flexure to the lateral abdominal wall below the liver. It bounds below a peritoneal depression at the entrance of the foramen of Winslow. The fold has been named the right *colico-phrenic* ligament, and is of some importance in operations on the gall-bladder.

The **Transverse Colon** extends from the right hypochondrium through the umbilical region to the left hypochondrium, where it becomes bent to form the *splenic flexure* (fig. 162, p. 88). The splenic flexure disappears beneath the lower three ribs and diaphragm, but when pulled downwards it is seen to come into contact with the spleen at the *colic impression* (fig. 163, p. 89), an impression at the lower end and inner surface of the spleen. The left *colico-phrenic* peritoneal ligament joins the splenic flexure near its termination to the inner aspect of the diaphragm (fig. 153, 14, p. 67). The ligament forms a shelf for the lower end of the spleen. The transverse colon is enclosed in peritoneum (fig. 160). The transverse meso-colon binds it to the posterior abdominal wall, over the lower border of the pancreas and over the second part of the duodenum (fig. 159). The transverse meso-colon forms part of the posterior wall of the lesser sac (fig. 160). Over its upper or omental tænia are attached the two posterior layers of the great omentum.

The transverse colon lies along the greater curvature of the stomach. When the stomach is empty and the bowel full, it comes to lie in front of the stomach. When the belly-wall is opened in the gastric triangle, the transverse colon may present itself instead of the stomach. The walls of the stomach are to be recognised by their thickness and absence of tæniæ. The attachment of the gastro-hepatic omentum to the organ assures the surgeon that he is dealing with the stomach. The student will note that the splenic flexure occupies the angle between the stomach and spleen, and that the left dome of the diaphragm is filled by these three organs (fig. 185, p. 145).

The **Descending Colon** passes vertically downwards in the left lumbar region until it reaches the level of the crest of the ilium. Then it passes into the sigmoid colon. The descending colon was already exposed and examined in the left lumbar region (fig. 118, p. 3). When empty, the peritoneum, as a rule, just covers it, but when distended a considerable part of the posterior surface is bare and outside the peritoneum. It is of smaller diameter, and more completely covered by peritoneum, than the ascending colon. Formerly it was opened in the lumbar region for organic obstructions of the rectum and sigmoid colon. The surgeon now prefers opening the sigmoid in the left groin. The descending colon lies in front of the kidney, quadratus lumborum and its fascia, and to the outer border of the psoas.

The **Sigmoid Colon** (fig. 129, p. 20) lies in the left iliac fossa and extends from the crest of the ilium to the brim of the pelvis, where it joins the first stage of the rectum. It crosses the psoas, left common iliac vessels and the ureter, on the left brim of the pelvis, over the left sacro-iliac synchondrosis.

The sigmoid colon is completely covered by peritoneum, but the length of its mesentery, the meso-sigmoid, is extremely variable. In the early human fœtus the meso-sigmoid is free, contains the inferior mesenteric vessels, and fixes the bowel in front of the spine. Soon the pressure of the small gut above it pushes it against the iliac fossa, to which it may adhere partially or completely (fig. 153, 34, p. 67). The inter-sigmoid fossa, found beneath the meso-sigmoid, is formed as the mesentery adheres to the parietal peritoneum over the iliac fossa. The sigmoid colon is situated above the outer half of Poupart's ligament, and in nine bodies out of ten lies superficially in the groin and is easily found by the surgeon.

Many anatomists prefer to regard the sigmoid colon and the first stage of the rectum as parts of the same loop. To this the name of *Omega Loop* is given because of its shape. The omega loop is suspended by a fan-shaped fold of mesentery to the left brim of the pelvis (fig. 129, p. 20).

First Stage of the Rectum.—The first stage of the rectum is completely covered by peritoneum and suspended by the meso-rectum. It commences on the left brim of the pelvis, over the left sacro-iliac synchondrosis, and ends in front of the third sacral vertebra. As already mentioned, it forms, with the sigmoid colon, an omega-shaped loop, the meso-sigmoid and meso-rectum being parts of the same peritoneal sheet. The first part of the rectum lies in the pelvis and is about three or four inches long. The superior hæmorrhoidal vessels, nerves, and lymphatics lie in the meso-rectum (fig. 153, 41, p. 67).

The longitudinal muscular fibres which are collected in tæniæ on the colon and first stage of the rectum spread out on the second stage of the rectum and form a continuous covering.

The **Second Stage of the Rectum** was already exposed in the sacral region (fig. 128, p. 17). It extends from the third piece of the sacrum to a point 1½ inches beyond the tip of the coccyx, where it ends in the third stage—the ANAL CANAL. The posterior surface of the second stage is destitute of peritoneum, and only the upper half of its anterior surface is covered. The peritoneum is reflected from it to the sides of the pelvis, passing forwards to the uterus in the female and to the bladder in the male.

The pelvic part of the gut will be examined further in the dissection of the pelvis.

The Spleen.—The spleen is now to be pulled forwards and examined. It frequently adheres somewhat firmly to the front of the left kidney and considerable force is required.

SURFACES.—The four surfaces should be examined while the organ is *in situ*:

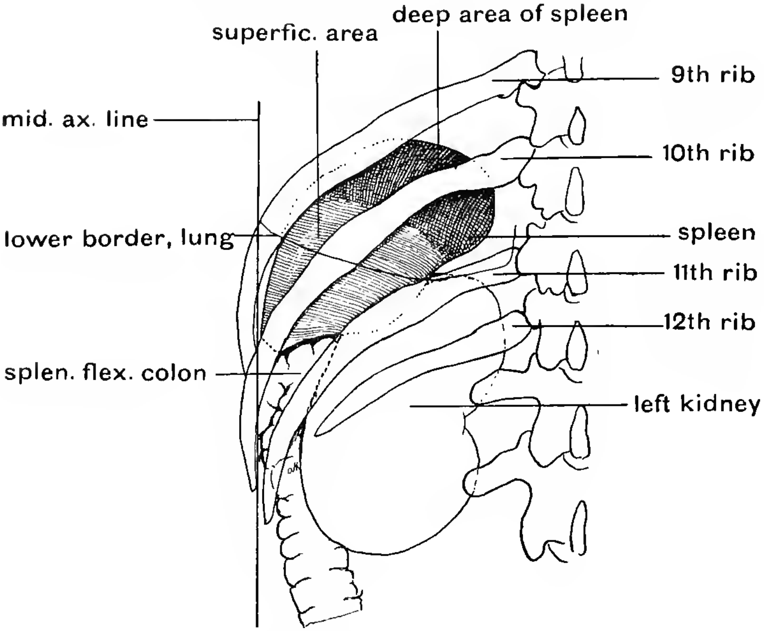
(1) The *diaphragmatic*, oval, convex and smooth, and completely covered by peritoneum. It lies in the dome of the diaphragm and beneath the posterior segments of the ninth, tenth, and eleventh ribs (fig. 162). The axis of the spleen is oblique and parallel with the ribs. The anterior or lower extremity of this surface lies close to the mid-axillary line; the posterior or upper end of the surface, as indicated on the back, is about 1½ inches distant from the line of the spinous processes. It will thus be seen that the spleen is to be percussed out on the postero-lateral aspect of the body. It must be remembered that the pleura and lung, as well as the diaphragm and chest-wall, separate the diaphragmatic surface of the spleen from the skin of the back and side (fig. 162). It moves downwards and forwards in inspiration, and upwards and backwards as the stomach or colon becomes full.

(2) The *gastric surface* is slightly concave and applied to the posterior aspect of the fundus of the stomach (fig. 157, p. 75, and fig. 159). The anterior border, which separates the gastric and diaphragmatic surfaces, is commonly notched or

crenated (fig. 163). The gastro-splenic omentum is attached along the posterior margin of the gastric surface (figs. 157 and 163).

(3) The *colic surface* is situated on the inner aspect of the lower or anterior extremity of the spleen (figs. 159 and 163). The splenic flexure is in contact with it. It is covered by peritoneum. Just above the colic surface the tail of the pancreas will be seen to come in contact with the spleen.

Fig. 162.—The position and relationships of the spleen. The deep and superficial areas of its diaphragmatic surface are exposed.



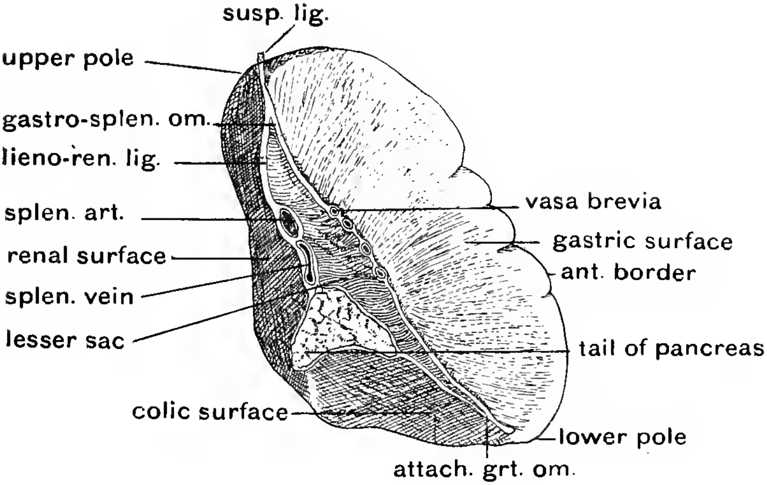
(4) The *renal surface* (fig. 163) cannot be well seen now, but can be felt by passing the hand behind the spleen. It is applied to the anterior or outer surface of the left kidney and supra-renal capsule (fig. 157, p. 75). In the young it is completely covered by peritoneum, but in the adult, part of the surface adheres to the parietal peritoneum over the left kidney.

The *hilum* of the spleen lies between the gastric, renal, and colic surfaces (fig. 163). There the splenic arteries enter and the veins emerge. There, too, the lieno-renal ligament and gastro-splenic omentum are attached.

Fixation of the Spleen.—Certain folds of peritoneum retain the spleen in position: (1) The lieno-renal; (2) the lieno-phrenic or suspensory ligament; (3) the gastro-splenic; (4) the left colico-phrenic, supporting its lower end.

(1) The *lieno-renal* ligament (fig. 157, p. 75) is a double fold of peritoneum which binds the spleen to the front of the left kidney and supra-renal body. It helps to bound the lesser sac (fig. 153, 12, p. 67). When opened, the peritoneum of the lesser sac is seen to be reflected to the hilum of the spleen, forming the inner layer of the ligament. The outer layer is formed by a reflection of the parietal peritoneum (fig. 157, 13, p. 75). Through the lieno-renal ligament the arteries and veins reach and leave the spleen (fig. 157).

FIG. 163.—DIAGRAM OF THE GASTRIC, RENAL, AND COLIC SURFACES OF THE SPLEEN.



(2) The *lieno-phrenic* ligament suspends the upper and posterior end of the spleen to the diaphragm. It is continuous with the gastro-phrenic ligament and upper end of the gastro-splenic omentum (fig. 153, 42, p. 67).

The gastro-splenic omentum and colico-phrenic ligament have been already examined (pp. 74, 85).

After the blood-vessels of the abdomen have been dissected, the organs just described should be removed from the body and examined more minutely.

THE BLOOD SUPPLY OF THE ABDOMINAL VISCERA

The **Abdominal Aorta** enters the abdomen in front of the spine between the crura of the diaphragm at the twelfth dorsal vertebra, and, passing down to the lower border of the fourth lumbar vertebra, divides into right and left common iliac arteries. It gives off three great vessels to supply the alimentary tract and its glandular appendages. These are:

(1) The *cœliac axis,* which comes off as soon as the aorta appears in the abdomen (fig. 158, p. 76).

(2) The *superior mesenteric* artery, half an inch lower down (fig. 164).

(3) The *inferior mesenteric,* two inches lower down (fig. 165).

The veins which return the blood of these arteries unite to form the *portal vein,* which ends in the liver.

Superior Mesenteric Artery.—The great omentum and transverse colon should be thrown upwards over the costal margin, and the small intestines drawn towards the left side, so as to expose the mesentery. By dissecting off the anterior or right layer of mesentery, the superior mesenteric vessels will be exposed. The artery should be found as it crosses in front of the third stage of the duodenum (fig. 164, 10).

Course.—The superior mesenteric artery arises from the front of the aorta, just below the cœliac axis, and behind the pancreas. It emerges between the pancreas and the third part of the duodenum, which it crosses, and passes between the two layers of the mesentery. In the mesentery it passes with a curved course towards the ileo-colic junction.

As the student cleans the arteries, he will find them thickly coated with white fibrous material, which he may mistake for connective tissue, but which is in reality the nerves of the superior mesenteric plexus which pass from the solar plexus to the intestine on the coats of the arteries. The veins and lymphatic or lacteal vessels lie close to the arteries, and have to be removed. Numerous mesenteric lymph glands will also be encountered. Through these the chyle passes on its way from the intestine to the thoracic duct.

Branches.—The following branches are to be sought for (fig. 164):

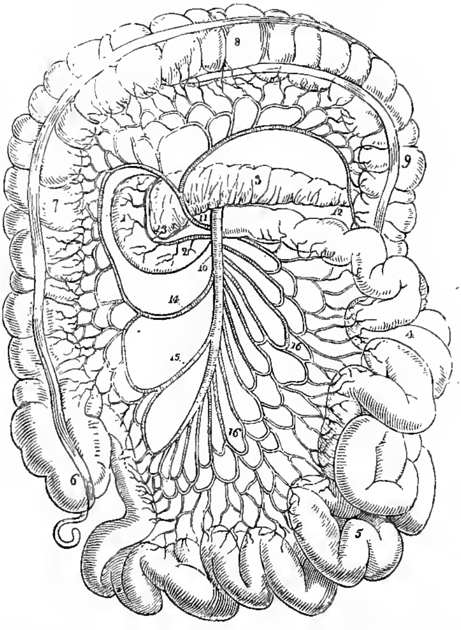
To the *left side*: Vasa intestini tenuis, twelve to fourteen in number (fig. 164, 16).

To the *right side*:

(1) Inferior pancreatico-duodenal (fig. 164, 13).
(2) Middle colic artery.
(3) Right colic artery.
(4) Ileo-colic artery.

(1) The *inferior pancreatico-duodenal* (fig. 164, 13) arises near the root of the vessel, and passes between the head of the pancreas and duodenum, supplying both structures, and anastomosing with the superior pancreatico-duodenal artery. The anastomosis may open up and from it a hepatic vessel may be given off.

FIG. 164.—THE DISTRIBUTION OF THE SUPERIOR MESENTERIC ARTERY. (*Wilson.*)



1. Descending portion of the duodenum. 2. Transverse portion. 3. Pancreas. 4. Jejunum. 5. Ileum. 6. Cæcum and appendix vermiformis. 7. Ascending colon. 8. Transverse colon. 9. Descending colon. 10. Superior mesenteric artery. 11. Colica media. 12. The branch which inosculates with the colica sinistra. 13. Pancreatico-duodenalis inferior. 14. Colica dextra. 15. Ileo-colica. 16, 16. Vasa intestini tenuis.

(2) The *vasa intestini tenuis* (fig. 164, 16, 16) are a series of arteries, about fourteen in number, given off from the left or convex side of the superior mesenteric artery. Each artery divides into an upper and lower branch, which unite and form a series of loops. From each loop a series of secondary branches are given off, which in turn form a series of secondary arches, and even a tertiary series of arches may be thus formed. From the ultimate arches, branches are given off to the jejunum and ileum. These form a series of anastomosing vascular annuli around the intestine. They end in the rich sub-

mucous capillary plexus from which the arteries to the villi spring.

(3) The *middle colic* artery (fig. 164, 11) passes to the transverse colon between the two layers of the transverse mesocolon. It divides into right and left branches. The right anastomoses with the right colic, and the left with the left colic.

(4) The *right colic* (fig. 164, 14) passes behind the peritoneum to the ascending colon, near which it divides into an ascending and descending branch (fig. 153, 29, p. 67). The ascending branch joins the middle colic and the descending the ileo-colic.

(5) The *ileo-colic* (fig. 164, 15) passes to the right iliac fossa, and supplies the cæcum and adjacent parts of the ileum and colon. The artery to the appendix should be followed. It is a branch of the ileo-colic which passes behind the termination of the ileum, and reaches the mesentery of the appendix in which it ramifies. The anterior cæcal branch will be found ramifying on the anterior surface of the cæcum (fig. 154, A, p. 70). As it crosses the ileo-colic angle, it raises a peritoneal fold which bounds the ileo-colic fossa above. The terminal part of the ileo-colic artery divides into a branch for the colon and another for the ileum.

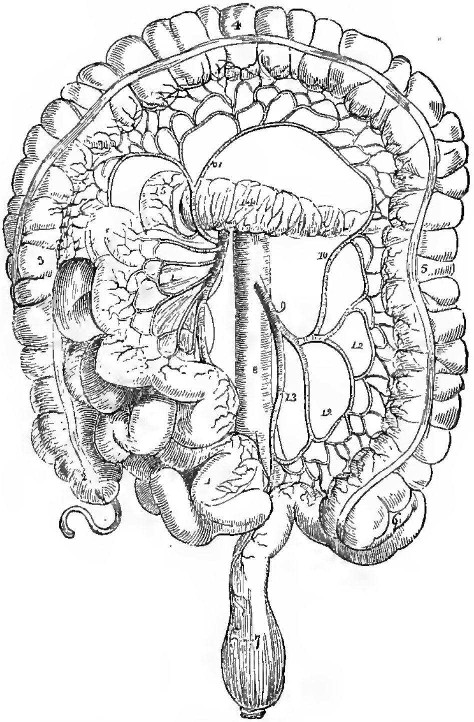
Each of the three colic arteries just described divides into branches which anastomose near the colon to form loops or arches from which branches are distributed to the intestine, an arrangement somewhat similar to that found in the vessels to the small intestine (fig. 164).

Superior Mesenteric Vein.—The superior mesenteric vein passes upwards on the right side of the artery and disappears under the pancreas to join the splenic vein—the vena portæ being thus formed (fig. 166). It receives branches corresponding to those of the artery. Beside these, however, a vein from the stomach, the *right gastro-epiploic*, joins it at the lower border of the pancreas.

Sometimes the superior mesenteric artery becomes blocked by an embolus. The result is that the bowel becomes gangrenous. The same effect is produced by thrombosis of the portal vein. The portal vein varies in size with the amount of blood it contains, and this in turn is due to the state of digestion. The coats of the vein contain an unusually large muscular element and are supplied with nerves, and thus the quantity of blood in the portal system may be regulated by the nervous system.

Nerve Supply of the Bowel.—The great coat of nerves, which the student saw on dissecting the arteries, is derived from the solar plexus. This will afterwards be seen behind the pancreas and on each side of the cœliac axis and origin of the superior mesenteric artery. Through these the size of the vessels is regulated, tone given to the bowel, and the sense of pain imparted. The sensory impulses, such as occur in colic, pass through the solar plexus and reach the spinal cord by the splanchnic nerves (fig. 175, p. 121).

Fig. 165.—The distribution of the inferior mesenteric artery. (*Wilson.*)



1, 1. The superior mesenteric, and small intestines turned over to the right side. 2. Cæcum and appendix vermiformis. 3. Ascending colon. 4. Transverse colon drawn upwards. 5. Descending colon. 6. Sigmoid flexure. 7. Rectum. 8. Aorta. 9. Inferior mesenteric artery. 10. Colica sinistra, inosculating with (11) colica media. 12, 12. Sigmoid branches. 13. Superior hæmorrhoidal artery. 14. Pancreas. 15. Descending portion of the duodenum.

Lacteals.—These are empty unless death has occurred during active digestion. The products of intestinal digestion pass partly by the portal vein and partly by the lymphatic (lacteal) vessels. The lacteal vessels pass through many isolated mesenteric glands and end in a group at the root of the superior mesenteric artery. From these, trunk vessels leave and join the receptaculum chyli, situated in front of the second lumbar vertebra and between the aorta and right crus. It will be seen later (fig. 176, p. 123).

Inferior Mesenteric Artery.—This artery is exposed by turning the small intestine over to the right side and then dissecting off the peritoneum from the lower part of the aorta and left side of the posterior abdominal wall (fig. 165).

COURSE.—The *inferior mesenteric* artery supplies the remaining part of the alimentary tract not supplied by the superior. It is distributed to the descending colon, sigmoid colon and rectum. It is much smaller than the superior mesenteric, and arises towards the left side of the aorta, about one and a half inches above its bifurcation. It passes down beneath the peritoneum on the posterior abdominal wall to the brim of the pelvis, where it terminates as the *superior hæmorrhoidal*, the principal artery of the rectum (fig. 153, 28, p. 67).

BRANCHES.—

(1) Left colic to the descending colon (fig. 165, 10).
(2) Sigmoid to the sigmoid colon (fig. 165, 12, 12).
(3) Superior hæmorrhoidal (fig. 165, 13) to the rectum, which, with the middle and inferior hæmorrhoidal arteries, small branches from the internal iliac and internal pudic, will be examined in the dissection of the pelvis.

The *left colic* and *sigmoid* branches divide and form arches which give off branches to the descending colon and sigmoid colon, in a manner precisely similar to the branches distributed to the other parts of the colon (fig. 165). Thus an arterial anastomotic chain is formed along the great gut from the cæcum to the rectum.

Inferior Mesenteric Vein.—The inferior mesenteric vein passes vertically upwards some distance to the left of the artery, and disappears under the pancreas to open into the splenic vein (fig. 166). Its tributaries correspond to the branches of the inferior mesenteric artery. The superior hæmorrhoidal vein, which receives blood from the rectum, commences in the veins beneath the mucous membrane of the anus. These sometimes become dilated and form piles. It will be seen that any obstruction to the course of the blood in the inferior mesenteric must be conducive to their formation, and therefore the student should follow its course with care. It receives the sigmoid and left colic veins as it passes upwards behind the peritoneum in the left lumbar region. It passes to the left of the duodeno-jejunal flexure. Its blood passes by the splenic vein to the portal vein, and thus to the liver (fig. 166).

The Cœliac Axis.—DISSECTION. Render the lesser omentum tense by drawing the stomach downwards and pushing the liver upwards. The liver and costal margin may be hooked aside. Open the lesser sac of the peritoneum, if not already opened, by tearing through the lesser omentum, and on removing the peritoneum of the posterior wall of the lesser sac, the cœliac axis will be exposed at the upper border of the pancreas (fig. 153, 10, p. 67).

It is frequently a matter of great difficulty to separate the liver and lesser curvature of the stomach far enough to allow a satisfactory dissection of this important trunk. If this is found to be the case, the stomach may be divided at the junction of its pyloric and cardiac parts. If the stomach contains fluid contents, these must be sponged out. The pyloric end of the stomach is then turned outwards to the right, and the cardiac pushed towards the left. Much less damage is done by a division of the stomach than by pulling the viscera apart and putting their natural relationships awry.

COURSE.—The *cœliac axis* is a short thick trunk, less than half an inch in length, which supplies blood to the stomach, spleen, pancreas, liver, and duodenum (fig. 158, p. 76). It is given off immediately above the pancreas, in front of the twelfth dorsal vertebra, and divides in a triradiate manner into three large vessels: (1) The coronary; (2) the hepatic; (3) the splenic. The short trunk is surrounded by the cœliac portion of the solar plexus (fig. 175, p. 121).

Coronary Artery (fig. 158, 12).—The *gastric* or *coronary* artery is the smallest branch of the cœliac axis. It passes at first upwards and to the left, behind the peritoneum of the lesser sac, raising and occupying a fold (fig. 153). It reaches the cardiac end of the stomach, and here it bends sharply downwards and courses from left to right along the lesser curvature of the stomach (fig. 158). It terminates near the pylorus by anastomosing with the pyloric branch of the hepatic artery. The coronary plexus of nerves surrounds the artery.

BRANCHES.—The gastric artery gives off: (1) *Œsophageal* branches, which pass upwards on the œsophagus and anastomose with the œsophageal branches of the thoracic aorta; (2) *Gastric* branches to both surfaces of the stomach; (3) *Omental* branches to the lesser or gastro-hepatic omentum.

CORONARY VEIN.—The *gastric* or *coronary* vein passes from right to left close to the artery, and having reached the posterior abdominal wall it joins the portal vein near the upper border of the pancreas (fig. 166).

Hepatic Artery (fig. 158, 1).—COURSE. The hepatic artery passes to the right, raising a fold of peritoneum on the posterior wall of the lesser sac (fig. 153). Passing at first above the pancreas, it then bends forwards and upwards in front of the foramen of Winslow in the gastro-hepatic omentum, to reach the transverse fissure of the liver, where it divides into the *right* and *left hepatic* arteries (fig. 156). These enter and supply the substance of the liver. As it lies between the layers of the lesser omentum, it has the common bile duct to its right side, and the portal vein behind it. The hepatic plexus of nerves passes from the solar plexus to the liver on and near the artery.

BRANCHES.—The hepatic artery gives off a number of important branches (fig. 158). They are:

(1) The pyloric.
(2) The gastro-duodenal:
  (*a*) The right gastro-epiploic.
  (*b*) The superior pancreatico-duodenal: this frequently arises separately from the hepatic.
(3) The cystic artery.
(4) Pancreatic branches.

(1) The PYLORIC artery (fig. 158, 3) passes to the lesser curvature of the stomach near the pylorus, and anastomoses with the gastric artery. It supplies branches to the pyloric end of the stomach.

(2) The GASTRO-DUODENAL artery (fig. 158, 13), a large vessel, passes downwards behind the first part of the duodenum, and divides into (*a*) the superior pancreatico-duodenal, and (*b*) the right gastro-epiploic arteries.

(*a*) The *superior pancreatico-duodenal* artery (fig. 158, 17) crosses the common bile-duct and passes downwards between the head of the pancreas and duodenum, and having supplied branches to both, anastomoses with the inferior pancreatico-duodenal, a branch of the superior mesenteric artery. It is the chief artery of the duodenum.

(*b*) The *right gastro-epiploic* artery (fig. 158, 23) passes from right to left on the larger curvature of the stomach between the layers of the great omentum, and having supplied branches upwards to both aspects of the stomach and downwards to the great omentum, it terminates by anastomosing with the left gastro-epiploic, a branch of the splenic artery (fig. 158).

(3) The CYSTIC artery (fig. 158, 7) is a small branch derived from the *right* hepatic artery. It divides near the neck of the gall-bladder into two branches, one passing between the gall-bladder and liver, the other ramifying in the free surface of the gall-bladder.

(4) PANCREATIC branches arise before the hepatic artery enters the gastro-hepatic omentum.

VEINS.—The superior pancreatico-duodenal and right gastro-epiploic veins join the termination of the superior mesenteric; the pyloric joins the portal (fig. 166). The cystic vein enters the right branch of the portal vein; the blood supplied to the liver by the hepatic artery enters the hepatic venous circulation.

Splenic Artery.—COURSE. The splenic artery is the largest of the three branches of the cœliac axis. It passes from right to left along the upper border of the pancreas and in front of the left kidney (figs. 153 and 158). It lies behind the lesser sac until it reaches the lieno-renal ligament, when it turns forwards to reach the hilum of the spleen (fig. 157). As it approaches the spleen it divides into a number of branches.

As the spleen moves with the filling stomach, to which it is bound by the gastro-splenic omentum, the splenic artery is tortuous to allow this movement to take place. The splenic vein lies below the artery and is partly hid by the pancreas. The splenic plexus of nerves passes to the spleen from the solar plexus along the splenic artery.

BRANCHES (fig. 158, p. 76) :—

(1) Splenic.
(2) Pancreatic.
(3) Left gastro-epiploic.
(4) Vasa brevia to the stomach.

(1) *Splenic.* Six or eight terminal branches enter at the hilum of the spleen between the gastric and renal surfaces (fig. 163). Within the spleen the arteries ramify and ultimately terminate in blood-spaces.

(2) The *pancreatic branches* are numerous. They are given off as the splenic artery passes along the pancreas. One, the *pancreatica magna*, is larger than the others, and runs from left to right in the substance of the pancreas close to the main duct.

(3) The *left gastro-epiploic* artery passes to the greater curvature of the stomach in the gastro-splenic omentum (fig. 157).

Having supplied gastric and omental branches, it terminates by anastomosing with the right gastro-epiploic artery (fig. 158, p. 76). It supplies branches to both surfaces of the stomach.

(4) *Vasa brevia* pass to the left extremity of the stomach in the gastro-splenic omentum. They supply both aspects of the fundus of the stomach.

It will be seen that the splenic artery, and its branches to the stomach, pass round the left extremity of the lesser sac (fig. 157, p. 75). To understand this anomalous arrangement, reference must be made to the condition in an early fœtal stage. At one time the greater curvature of the stomach is suspended from the posterior wall of the abdomen by a mesentery, through which the splenic artery reaches the stomach and in which the spleen and pancreas are developed. This mesentery afterwards forms the bounding walls of the lesser sac.

Splenic Vein.—The *splenic vein* lies below the artery and *behind* the pancreas (fig. 166). Having crossed the aorta, it joins the superior mesenteric vein to form the vena portæ. In addition to radicles corresponding to the branches of the splenic artery, the splenic vein also receives the inferior mesenteric vein.

The Portal Vein.—The portal vein collects the blood from the stomach, intestine, spleen, pancreas, and gall-bladder. It is a short trunk, about three inches in length, which is formed by the junction of the superior mesenteric and splenic veins behind the neck of the pancreas (fig. 166).

COURSE.—Two stages are to be recognised in the course of the portal vein, viz. post-pancreatic and omental (fig. 166).

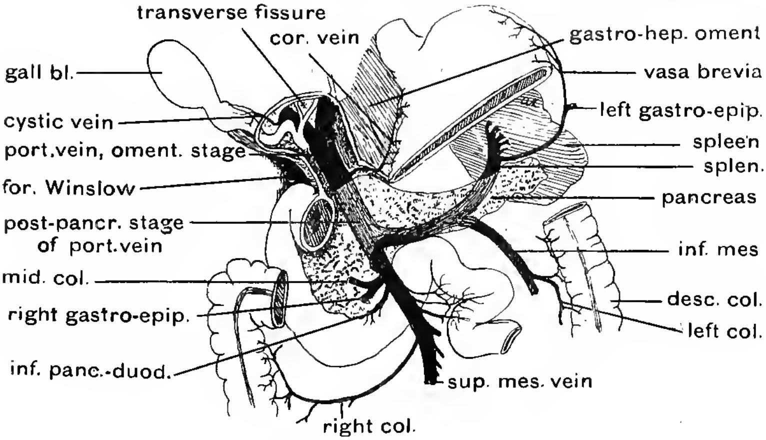
In the *post-pancreatic* stage the vein lies behind the neck of the pancreas, and grooves the head which separates it from the common bile duct. The gastro-duodenal branch of the hepatic artery and first stage of the duodenum cross in front of it (fig. 169). It lies to the right of the aorta and superior mesenteric artery, and in front of the inferior vena cava.

In the *omental stage* the vein lies in the gastro-hepatic omentum and in front of the foramen of Winslow. The common bile, hepatic, and cystic ducts lie in front and rather to the right of it; the hepatic artery in front and to its left.

In the transverse fissure of the liver it becomes somewhat dilated, and divides into right and left branches (fig. 166). These ramify in the right and left lobes of the liver after the manner of an artery, and end in the interlobular plexuses of the liver. The left branch is connected with the remnants of the ductus venosus and umbilical vein in the longitudinal fissure of the liver (fig. 172).

The portal blood passes through the lobular circulation, leaving the lobules by the intralobular veins. These unite to form the hepatic veins which enter the inferior vena cava as that vessel perforates the diaphragm.

FIG. 166.—THE FORMATION AND COURSE OF THE PORTAL VEIN. PART OF THE ANTERIOR LAYER OF THE GASTRO-HEPATIC OMENTUM IS CUT AWAY. (*Diagrammatic.*



TRIBUTARIES.—These have been already examined, but the following table may help to recall their number and the areas which they drain (fig. 166) :

(1) **Inferior Mesenteric** joins the splenic or occasionally the commencement of the portal vein.
 a. Superior hæmorrhoidal; *b.* Sigmoid; *c.* Left colic.

(2) **Splenic Vein.**
 a. Splenic; *b.* Vasa brevia; *c.* Left gastro-epiploic; *d.* Pancreatic.

(3) **Superior Mesenteric.**
 a. Vasa intestini tenuis; *b.* Ileo-colic; *c.* Right colic; *d.* Middle colic; *e.* Superior and inferior pancreatico-duodenal; *f.* Right gastro-epiploic.

(4) **Portal Vein.**
 a. Superior mesenteric; *b.* Splenic; *c.* Coronary; *d.* Pyloric; *e.* Cystic.

Structure of the Stomach.—A ligature is placed on the cardiac orifice of the stomach and the œsophagus divided above it. The gastro-splenic omentum, containing branches from the splenic artery to the stomach, is cut through. The gastro-hepatic omentum is also divided—except the part containing the bile ducts and portal vein, which, with the pyloric sphincter and an inch of the pyloric end of the stomach, must be left *in situ*. This is necessary in order that the important relationships of the bile ducts may be retained. The cardiac end of the stomach, and the greater part of the pyloric, may then be removed, laid open, and examined.

The following points are to be noted:

(1) Coats; the serous, muscular, submucous and mucous coats can be distinguished (fig. 167). The *submucous* coat is lax; when the muscular coat is contracted, the submucous coat is lax enough to allow the mucous membrane to be thrown into folds. It is only in complete distension that the mucous coat is spread evenly out. In the submucous coat there is a rich plexus of vessels and nerves. The vascular plexus in the mucous membrane is fed from it.

(2) On the inner surface of the stomach, pits marking the openings of the gastric glands in the *mucous* membrane can be made out. At the cardiac orifice a slight valvular fold of mucous membrane can commonly be distinguished. The cardiac orifice is closed naturally by the mucous membrane which lines it being thrown into folds by the contraction of the muscle fibres of the terminal part of the œsophagus.

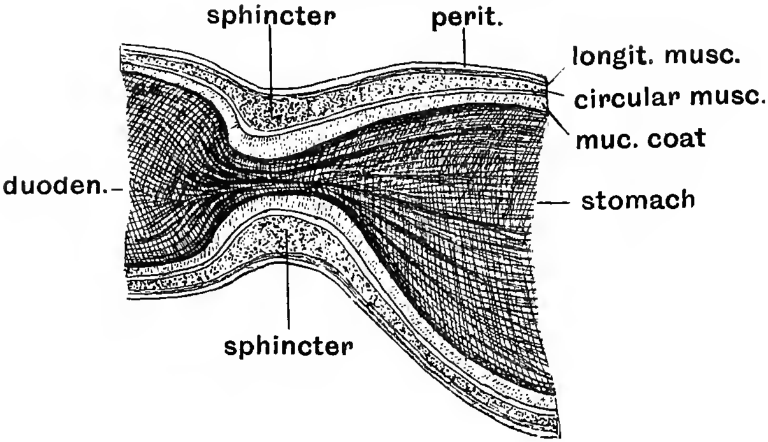
(3) Three layers are distinguished in the *muscular coat* of the stomach, but they are not sharply demarcated from each other. The outer coat is made up of longitudinal fibres, most thickly distributed on the lesser and greater curvatures, and continuous with the longitudinal fibres of the œsophagus. The deepest layer is oblique, but commences as circular fibres on the fundus of the stomach. The middle layer is made up of fibres arranged in a circular direction.

(4) The *pyloric sphincter* should be examined *in situ*. In life it guards the escape of gastric contents, which have to be forced through it by the contraction of the stomach.

The fore-finger should be pushed through it into the duodenum. It's nature is best exposed by such a section as is shown in fig. 167. The sphincter muscle is a strong ring, continuous with the circular fibres of the stomach on the one hand and with those of the duodenum on the other. It gives rise to a diaphragm or iris of mucous membrane between the duodenum and stomach, abrupt on the duodenal aspect, sloping on the gastric (fig. 167). The submucous coat binds the mucous membrane firmly to the muscular coat in the pyloric region. Outside the sphincter, the longitudinal muscle fibres of the stomach become continuous with the longitudinal coat of the duodenum.

Mucous Membrane of the Duodenum.—The transverse colon and its meso-colon must be removed to expose the duodenum freely. Ligature the hepatic and splenic flexures before removal. The duodenum is to be left *in situ* (figs. 153 and 159). It is laid open along the convex border by an incision continuous with that used to open the pyloric sphincter. If the contents of the small gut are still fluid, an unusual occurrence in a formalin-preserved body, the duodeno-jejunal flexure must be ligatured. The contents of the duodenum are to be cleaned away with tow.

Fig. 167.—The sphincter of the pyloric orifice of the stomach.



The following points are then to be examined :

(1) *Vater's papilla* and *ampulla* on the inner wall of the second stage, just above the 'syphon bend.' The common bile and pancreatic ducts open in the ampulla (figs. 169 and 170). Below the ampulla is a vertical ridge of mucous membrane from

which low circular folds, valvulæ conniventes, pass outwards on each side of the gut. These distribute the digestive juices among the products of gastric digestion (fig. 169).

(2) The *valvulæ conniventes* begin below the opening of the bile and pancreatic ducts, and form semicircular or crescentic folds of mucous membrane, which enormously increase the surface for absorption.

(3) *Villi* commence on the duodenal aspect of the pyloric sphincter; they extend along the whole length of the small gut and terminate at the ileo-cæcal opening.

(4) By picking away the mucous membrane of the first stage of the duodenum, *Brunner's glands* can be seen as pea-like nodules in the submucous tissue. They are small, acino-tubular glands, which open on the mucous membrane.

Mucous Membrane of the Jejunum, Ileum, and Colon.—A foot of the jejunum and another of the ileum should be removed for examination between double ligatures. When washed out, the points of difference mentioned on p. 80 should be verified. At the same time a piece of the transverse colon should be washed out and its structure compared with that of the small intestine.

The *mucous membrane* of the small intestine presents certain distinctive features in the form of villi, valvulæ conniventes, and Peyer's patches.

The *villi*, best seen under water, give to the mucous membrane its velvety character. They occur throughout the whole of the small intestine, but are better marked and more numerous in the jejunum than in the ileum.

The *valvulæ conniventes* are crescentic transverse folds of the mucous membrane, supported by thickenings of the submucous tissue, and increase the absorptive and secreting surface. They are not obliterated by distension or extension of the gut. They may be crescentic folds, complete rings, or even spiral double rings, especially in the upper part of the small intestine. The valvulæ conniventes are most numerous in the duodenum and jejunum; they become fewer in number in the upper part of the ileum, and disappear entirely about the middle of that tube.

Peyer's patches are collections of lymphoid follicles found only in the ileum, very rarely in the jejunum. They are better marked in the young subject than in the old. They become ulcerated in typhoid fever. In shape they vary, being sometimes circular, more frequently oblong, and may be from half an inch to two inches in length. When oblong they are placed lengthwise on the gut on the side *opposite* the attachment of the mesentery. They are largest and most numerous in the lower end of the ileum.

It will thus be noticed that the villi and valvulæ conniventes are better developed in the jejunum, while Peyer's patches are almost peculiar to the ileum.

The *mucous membrane of the large intestine* is devoid of villi, valvulæ conniventes, and Peyer's patches, and is uniformly smooth. It contains tubular glands.

Solitary lymphoid follicles occur in the mucous membrane of both large and small intestines.

Ileo-cæcal Valve (fig. 161, p. 83).—The cæcum, appendix, two inches of the ileum and ascending colon are to be removed; ligatures being placed on each side of the sites of division. The ascending meso-colon and termination of the mesentery are cut through in their removal. It was formerly the habit to wash out, inflate, and dry the cæcum and then examine the ileo-cæcal valve. A wholly artificial condition was thus produced, with no more resemblance to the real structure than an Egyptian mummy has to a living man. The cæcum and ascending colon are laid open by an incision passing along the whole of their right margin. The organ is then washed out.

The ileo-cæcal valve is then seen on the inner wall at the junction of the cæcum and ascending colon, as a pouting mouth, with *upper* and *lower* rounded lips, between which the ileum opens (fig. 161). The lips unite together in front and behind to form frena or *retinacula*, which give rise to horizontal shelf-like folds on the cæcum. They almost meet on the right wall of the cæcum; the posterior frenum is the better marked.

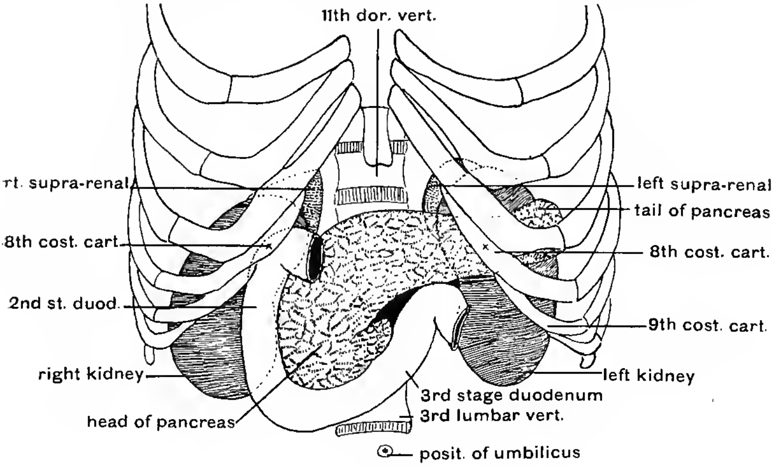
A section should be made so as to expose the termination of the ileum in the lips of the ileo-cæcal valve. The circular fibres of the ileum can be traced into the valve and act as an imperfect sphincter. The ileum, with the valve as an apex, is sometimes invaginated into the ascending colon, thus causing strangulation of the gut, for the mesentery is also drawn in and its vessels occluded by the pressure. The ileo-cæcal valve has probably rather the action of a sphincter than of a valve, and it is therefore possible for enemata to pass into the ileum.

Opening of the Appendix.—The appendix opens in the cæcum, a little below the ileo-cæcal aperture (fig. 161). Its size and shape vary, but as a rule only a catheter of small size can be passed into it. A fold of mucous membrane commonly guards the orifice.

Removal of the Intestine.—Only the duodenum and rectum are to be left in the abdomen. Ligatures are placed between these and the rest of the gut. The attachment of the mesentery and meso-colon to the posterior abdominal wall should be closely observed in the removal (fig. 153, p. 67).

The Pancreas.—The pancreas is a greyish, elongated, multi-lobulated gland, which lies across the posterior abdominal wall in the epigastric and left hypochondriac regions, behind the stomach and lesser sac of the peritoneum and opposite the twelfth dorsal and first lumbar vertebræ (fig. 168).

Fig. 168.—Showing the position of the pancreas. (*After Addison.*)



Its head is encircled by the duodenum, its tail touches the spleen; its body crosses the aorta in the fork between the cœliac axis above and the superior mesenteric artery below. A knowledge of its relationships is the key to the complicated arrangement of structures in the retro-gastric region. The pancreas is deeply situated; the stomach and liver cover and mask it so completely that it cannot be palpated from the surface of the abdomen. It consists of a head, neck, body, and tail.

The **head** is closely applied to the concavity of the duodenum. It is covered in front by the peritoneum which forms the posterior wall of the lesser sac; the transverse meso-colon is attached to its anterior surface (fig. 159, p. 78). The common bile duct passes down in its posterior part close to the duodenum (fig. 169). The vena cava and right crus lie behind it. The *beak*—a process from the lower part of the head—passes behind the superior mesenteric vessels. The pylorus rests on the anterior aspect of the head.

The **neck** of the pancreas is the part in front of the portal vein and superior mesenteric vessels (figs. 159 and 168). It unites the head and body.

The **body** of the pancreas has three surfaces. The *anterior* surface shows a well-marked prominence, the *omental tuberosity*, which fits against the lesser omentum. To the left of this there is a shallow *gastric depression*, on which the posterior surface of the stomach lies. This surface of the pancreas is directed forwards and upwards, forming a shelf and part of the 'stomach bed.' The transverse meso-colon is attached to its lower prominent border (fig. 159); the peritoneum covering the surface is part of the posterior wall of the lesser sac (fig. 160, p. 82). The cœliac axis appears at its upper border and gives off the hepatic and splenic arteries, which turn along the border to right and left.

The *posterior* surface is moulded on the posterior abdominal wall. From right to left it rests on (1) the aorta; (2) left crus of the diaphragm; (3) psoas muscle; (4) left kidney; (5) renal and supra-renal vessels.

The splenic vein passes inwards behind the pancreas near the upper border of the posterior surface (fig. 166). Behind and above the pancreas, on each side of the cœliac axis, lie the terminations of the great splanchnic nerves, the semilunar ganglia and solar plexus (fig. 175, p. 121).

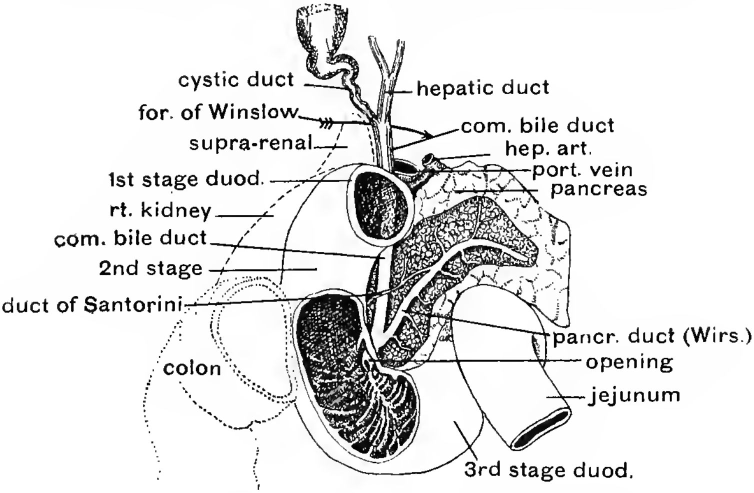
The *inferior* surface is narrow. It rests on the termination of the duodenum, the commencement of the superior mesenteric artery, and gives attachment to the transverse meso-colon at its anterior border (fig. 160).

The **tail** of the pancreas lies in front of the left kidney, and touches the spleen below its hilum (fig. 163). The splenic vessels lie at its upper border. The peritoneum of the lesser sac covers it; the transverse meso-colon is attached to it.

It will thus be seen that the pancreas is one of the most firmly fixed organs of the abdomen. Its relationships are so numerous, and with so many important structures, that occurrence of new growths within it must give rise to a widely spread disturbance.

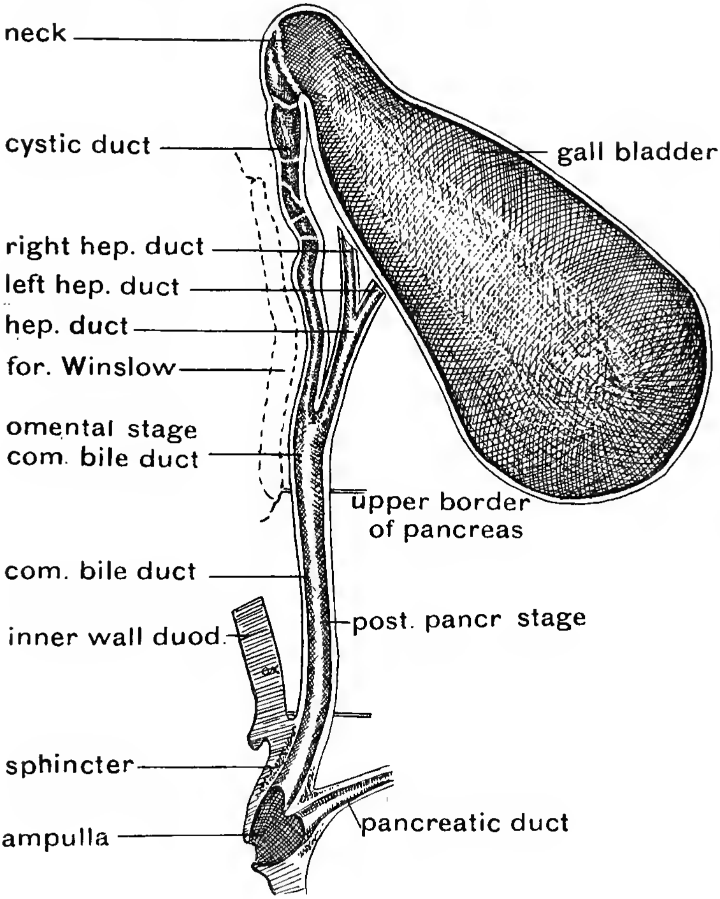
The **duct** of the pancreas, or *duct of Wirsung*, extends from the tail to the head of the pancreas; here it receives a secondary duct from the lower part of the head. Frequently an accessory duct—the *duct of Santorini*—is present in the upper part of the head. It opens in the duodenum half an inch nearer the pylorus than the main duct, with which it is in communication (fig. 169). The main duct can be found most easily on the posterior aspect of the pancreas, and should be dissected out with the bile ducts (fig. 169).

FIG. 169.—THE HEAD OF THE PANCREAS, DUODENUM, AND COMMON BILE-DUCT.



Bile Ducts.—The bile formed in the right lobe of the liver ultimately passes to the right hepatic duct, that in the left lobe to the left hepatic duct; the two hepatic ducts lie in the transverse fissure of the liver (fig. 166). As they enter the gastro-hepatic omentum, they unite to form the common hepatic duct, a vessel about one inch in length (fig. 169). The hepatic duct becomes continuous with the common bile duct, the point of union being marked by the junction of the cystic duct (fig. 170). Through this duct the gall-bladder communicates with the bile passage formed by the hepatic and common bile ducts. The common bile duct is three inches long and ends in the second stage of the duodenum. Thus the bile reaches the duodenum from the liver by the right and left hepatic and common hepatic and bile ducts. Bile contained within the gall-bladder enters the duodenum by the cystic and common bile duct.

Fig. 170.—The gall-bladder and bile-ducts viewed from the right.



Common Bile Duct.—The common bile duct is now to be dissected. Recent advances in the operative treatment of gall-stones give an enhanced importance to the structure and relationships of the bile passages. The duct has already been seen in the gastro-hepatic omentum, in front of the foramen of Winslow (fig. 166). The duct presents in its course two distinct stages—omental and retro-duodenal (figs. 169 and 170).

The OMENTAL STAGE is about one inch long. It lies in the right free edge of the gastro-hepatic omentum, in front of the foramen of Winslow. The portal vein lies behind it; the hepatic artery to its left side. It is tough and strong, and normally is of the diameter of a goose-quill, but if the subject has suffered from gall-stones, as is frequently the case, its lumen may easily take a lead pencil. Fibrous tissue surrounds the duct; it contains nerves, and numerous lymph vessels passing down from the liver to the glands at the upper border of the pancreas. There are one or two lymphatic glands lying beside it in the omentum.

THE RETRO-DUODENAL OR POST-PANCREATIC STAGE.—The pylorus and first stage of the duodenum are turned to the right and the duct followed into the head of the pancreas. This stage is two inches long, and lies behind the first stage of the duodenum and head of the pancreas (fig. 169). The superior pancreatico-duodenal artery crosses over the duct. As it is followed down deep in the head of the pancreas, it is seen to lie between the pancreas and the second stage of the duodenum, on the inner wall of which it terminates. Just before its termination the delicate white duct of the pancreas will be seen to join it (fig. 169).

The **pancreatic duct** (duct of Wirsung) passes towards the right in the pancreas, much closer to the posterior than to the anterior surface of the gland. Tributary ducts are seen to join it. A considerable duct reaches it from the beak and lower part of the head. A second duct (duct of Santorini) may be present and open into the duodenum half an inch nearer the pylorus than the main duct.

The common bile and pancreatic ducts open together in the *ampulla of Vater*, a minute diverticulum on the inner wall of the duodenum above the ‘syphon bend’ (fig. 170). Its upper margin is prolonged into a papilla within the duodenum. A diverticulum of the duodenum is frequently found above the opening of the common bile duct. The termination of the duct is surrounded by fibrous tissue, in which a sphincter muscle occurs (fig. 170). The contraction of this sphincter may have to do with the regurgitation of the bile from the hepatic to the cystic duct to fill the gall-bladder.

The *cystic* and *hepatic ducts* also lie in the gastro-hepatic omentum (fig. 170). They will be dissected with the liver.

THE LIVER

The student should have before him a liver from the store specimens; otherwise he will have much difficulty in understanding the manner in which the organ is fixed in the body.

POSITION.—(1) *Lower Limit.* The superficial *infra-sternal area* of the liver should be noted (fig. 129, p. 20). It appears in the sub-costal angle, its lower border passing between the eighth left and the ninth right costal cartilages. The attenuated extremity of the left lobe lies under the heart, separated from it by the diaphragm and pericardium only. In women, it may extend far to the left and come in contact with the spleen. As a rule the lower margin of the right lobe corresponds with the margin of the thorax, but an infinite degree of variation is seen, depending on the condition of the diaphragm and abdominal viscera. Not infrequently the margin of the right lobe, under the tenth cartilage, is prolonged into a process below the tenth right costal cartilage (Riedel's lobe). The right lobe rests behind on the upper part of the right kidney, which separates it from the twelfth rib.

(2) *The Upper Limit of the Liver.*—The liver fills the right dome of the diaphragm, hence the line which marks the diaphragm on the surface of the thorax also indicates the upper border of the liver. The diaphragm rises and falls about an inch with each breath. The dome of the liver reaches its highest point in the line of the nipple; there it reaches the fifth rib. A line drawn from the highest point to below the apex beat, through the insertion of the seventh pair of cartilages, marks out the upper border of the liver on the anterior surface of the body. On the right side of the body the upper border of the liver is marked by a line drawn from the highest point to the tenth dorsal spine. It must be remembered, however, that the base of the lung is hollow and fits like a cap on the dome of the diaphragm and liver. Hence the upper part of the liver has to be percussed out through the lung.

The *fundus of the gall-bladder* projects below the ninth right costal cartilage.

FIXATION.—The liver is now to be removed and the manner in which it is fixed examined. It occasionally becomes displaced, slipping partly out from the diaphragmatic cup into the infra-costal region.

The liver is retained in position by:

(1) The abdominal viscera being pressed against its lower surface by the abdominal walls.

(2) The gastro-hepatic omentum. This has now to be completely divided. This ligament attaches the stomach to the liver.

(3) The falciform ligament, which has been already examined (p. 61). This is now divided. It is loose and plays only a small part in fixing the liver. It contains the round ligament in its free border (fig. 172).

(4) The left lateral ligament fixes it to the under surface of the diaphragm (fig. 153, 4, p. 67).

(5) The right lateral, coronary, and caval ligaments fix the non-peritoneal area of the posterior surface firmly to the diaphragm and inferior vena cava (fig. 171). These form by far the chief bonds of the liver. The coronary ligament is the reflected fold of peritoneum which fills the interval between the right lateral, falciform, and left lateral ligaments (fig. 171, 9, 10, 14). The right lateral ligament is the reflection of peritoneum which surrounds the right side of the posterior bare area (fig. 171, 11). In this uncovered area, bounded by the peritoneal reflections of the coronary ligament, is situated the inferior vena cava, which also fixes the liver to the diaphragm. The caval ligament is the connective tissue between the vena cava and the inferior or anterior surface of the diaphragm (fig. 171).

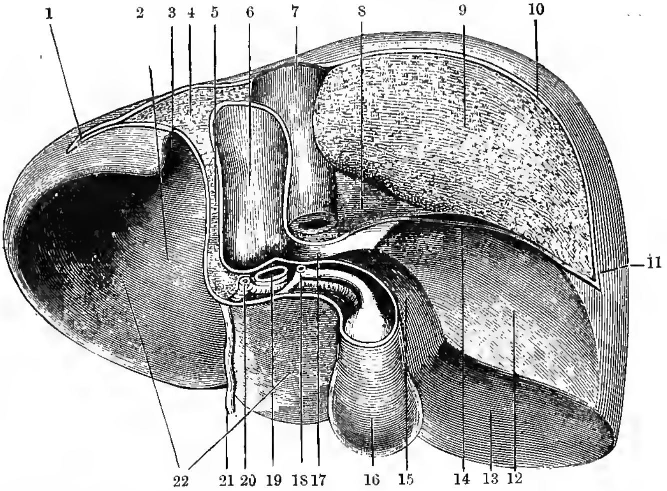
The vena cava is cut above and below the liver and removed with it. The right lateral, coronary, and caval ligaments are cut at the same time and the liver is withdrawn. As the liver is removed notice the oblique or Spigelian sinus of the lesser sac, which passes up between the Spigelian lobe and the right crus of the diaphragm (fig. 171, 6). This acts as a bursa between the diaphragm and liver.

Surfaces of the Liver.—As the liver lies *in situ*, it is seen that it possesses but two surfaces: a *diaphragmatic*, applied to the concavity of the diaphragm; a *visceral* or *inferior*, in contact with other viscera of the abdomen.

The DIAPHRAGMATIC SURFACE is divided into (1) superior; (2) anterior; (3) right lateral; (4) posterior.

The INFERIOR or VISCERAL SURFACE shows (fig. 171): (1) A *Renal area*, directed more backwards than downwards; (2) *Gastric*, in contact with the stomach; (3) *Duodenal*, on the quadrate and right lobes, in contact with the first stage of the duodenum; (4) *Colic* area, in contact with the hepatic flexure of the colon. The three areas named last are directed downwards.

FIG. 171.—THE POSTERIOR AND UNDER SURFACES OF THE LIVER, SHOWING THE LINE AT WHICH THE PERITONEUM IS REFLECTED FROM THE LIVER TO THE DIAPHRAGM. (*Anderson, in Heath's 'Anatomy.'*)



1. Cut edge of left lateral ligament. 2. Tuber omentale of left lobe. 3. Œsophageal notch. 4. Surface of liver uncovered by peritoneum. 5. Fissure of ductus venosus. 6. Spigelian lobe with cut edge of peritoneum of lesser sac. 7. Vena cava. 8. Impression for suprarenal capsule. 9. Portion of liver between layers of coronary ligament. 10. Cut surface of upper layer of coronary ligament. 11. Cut edge of right lateral ligament. 12. Renal impression. 13. Colic impression 14. Cut edge of coronary ligament, inferior layer. 15. Duodenal impression. 16. Gall-bladder. 17. Lobus caudatus. 18. Common bile-duct. 19. Portal vein. 20. Hepatic artery. 21. Round ligament. 22. Gastric impression on left and quadrate lobes.

Lobes and Fissures.—The *longitudinal fissure* divides the liver into two lobes, *right* and *left*. The anterior part of the fissure lies in the inferior surface; the posterior half lies in the posterior surface (fig. 172).

On the RIGHT LOBE there are three secondary lobes. They are (fig. 172):

(1) *Spigelian*, on the posterior surface between the posterior

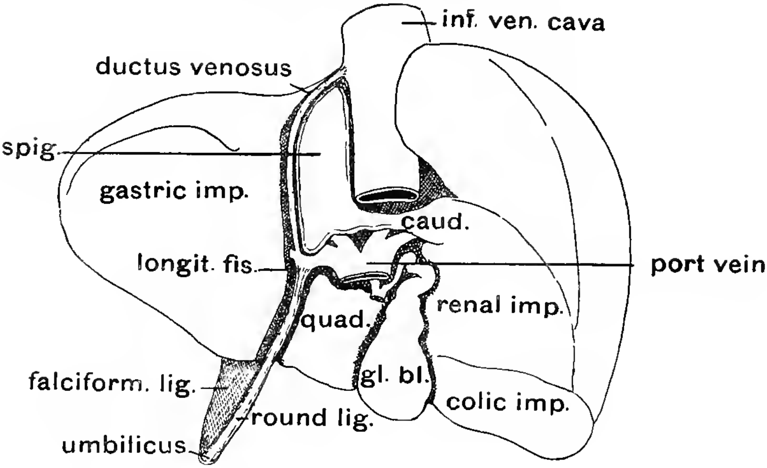
longitudinal and caval fissures. Its lower end projects on the under surface of the liver.

(2) *Caudate*, a narrow bridge of hepatic tissue between the Spigelian and right lobe of the liver. The *transverse fissure* bounds it in front (fig. 172).

(3) *Quadrate lobe.* Between the anterior part of the longitudinal fissure and the gall-bladder. The transverse fissure bounds it behind (fig. 172).

Remnants of the Fœtal Circulation, seen in connection with the Liver.—Two remnants of the fœtal circulation are now to be dissected out. They are the vestiges of the *umbilical* *vein* which brought the blood from the placenta, and the *ductus venosus*, which afforded the umbilical blood a short cut to the inferior cava and right auricle.

FIG. 172.—THE REMNANTS OF THE FŒTAL CIRCULATION SEEN IN CONNECTION WITH THE LIVER. (*Diagrammatic.*)



The **ligamentum teres** or round ligament (fig. 172), the remnant of the umbilical vein, will be found in the falciform ligament and longitudinal fissure on the under surface of the liver. It ends in the ductus venosus and left branch of the portal vein—for part of the placental blood passed through the liver in fœtal life. The ligament may be bridged over by hepatic tissue.

The fibrous remnant of the **ductus venosus** is found in the longitudinal fissure on the posterior surface of the liver (fig. 172). It is a fibrous cord between the round ligament and inferior vena cava. The ductus venosus enters the inferior vena cava as that vessel perforates the diaphragm. It lies in the attachment of the gastro-hepatic omentum to the longitudinal fissure (fig. 156, p. 73).

EXAMINATION OF THE SURFACES AND LOBES OF THE LIVER AFTER REMOVAL FROM THE BODY.—The *superior*, *anterior*, and *right lateral* surfaces are mere sub-divisions of one continuous, unequally convex surface, which is covered by peritoneum, and is in contact with the diaphragm and anterior abdominal wall. The superior surface is somewhat horizontal, the anterior surface slopes downwards and forwards, and the right lateral surface is almost vertical. No sharp line can be drawn between these three surfaces.

Attached to the upper and anterior surfaces is the *falciform ligament*, which stretches from the liver to the diaphragm, and separates the areas of the right and left lobes.

The *anterior free margin* of the liver is sharp and well defined. This free margin is interrupted by two notches: one, which is shallow, lying over the fundus of the gall-bladder, just below the ninth costal cartilage; the other, lying more internally, is deep and narrow, and receives the obliterated umbilical vein, or *round ligament* of the liver.

The INFERIOR SURFACE OF THE LEFT LOBE presents, near the longitudinal fissure, a rounded prominence, the *omental tuberosity* (fig. 171, 2); this rests on the surface of the lesser omentum. To the left of this eminence is a shallow concavity, the *gastric impression*, which is in contact with the convex anterior surface of the stomach.

The INFERIOR SURFACE OF THE RIGHT LOBE is subdivided by the transverse and cystic fissures, and is for the most part moulded to the surface of several abdominal organs. The **transverse** or **portal fissure** lies near the hinder limit of this surface (fig. 171). Around its margin is the attachment of the layers of the gastro-hepatic or lesser omentum. Entering or emerging at the two extremities of this fissure are (1) the right and left branches of the hepatic artery, (2) hepatic ducts, and (3) portal vein. These structures are accompanied by (4) lymphatics and (5) nerves, and surrounded by a sheath of connective tissue, (6) *the capsule of Glisson*. The hepatic duct is the most anterior, and the portal vein the most posterior, of the structures in the fissure.

The cystic fissure, which receives the gall-bladder, is broad and shallow, and extends from the right extremity of the transverse fissure to the anterior border of the liver. In front of the transverse fissure, and limited laterally by the longitudinal and cystic fissures, is the *quadrate lobe,* the surface of which is flattened or depressed, and lies in contact with the pylorus and the first part of the duodenum (fig. 171).

Behind the transverse fissure is a narrow strip of liver substance, a vestigial lobe, the *lobus caudatus* (fig. 172), which connects the inferior surface of the right lobe with the lower end of the Spigelian lobe. Near the point of union the Spigelian lobe presents a rounded elevation.

The remaining portion of the under surface of the right lobe is marked by three impressions, two large and one small (fig. 171). The large anterior impression corresponds to the hepatic flexure of the colon—*colic impression.* Behind this is a large impression for the right kidney, *renal impression.* Near the neck of the gall-bladder is the *duodenal impression*; this corresponds to the junction of the first and second portions of the duodenum.

The POSTERIOR SURFACE OF THE LIVER (fig. 171) is mainly occupied by a slightly convex surface devoid of peritoneum, which rests directly against the diaphragm. At the upper and lower limits of this 'bare area' will be seen the cut edges of the upper and lower layers of the coronary ligament. To the left of this bare surface is the deep fissure for the inferior vena cava. On opening the upper part of this vein, the hepatic veins will be seen entering.

To the left side of the inferior vena cava the posterior surface is hollowed out for the vertebral column and diaphragm, and is mainly occupied by the *Spigelian lobe,* which projects downwards as a well-defined mass into the upper or Spigelian recess of the lesser sac of the peritoneum (figs. 153 and 171). To the left of the Spigelian lobe is the *fissure* for the *ductus venosus.* Still further to the left will be seen a portion of the left lobe of the liver which is slightly impressed by the abdominal portion of the œsophagus.

The Bile Ducts.—The bile ducts commence within the liver in the biliary capillaries. By numerous successive junctions the *right* and *left hepatic ducts* are formed and emerge from the liver at the transverse fissure. These two ducts soon unite and form the *common hepatic duct* (fig. 169). The hepatic duct, after a course of about an inch in the gastro-hepatic omentum, is joined at an acute angle by the *cystic duct.* The *common bile duct,* or *ductus communis choledochus,* is thus formed. It has been already examined (fig. 170).

Gall-bladder (fig. 170).—The gall-bladder is situated in a depression on the under surface of the right lobe of the liver. Its rounded fundus projects beneath the lower margin of the liver at the ninth costal cartilage, but frequently it is found at some distance below the costal margin. The axis of the bladder is oblique, the fundus being directed downwards and to the right. The surgeon opens the fundus to remove gall-stones, its superficial position making the operation comparatively easy. It lies at the outer border of the rectus muscle, and above the transverse colon and pyloric end of the stomach.

The peritoneum is reflected over its fundus and lower surface, and binds the bladder to the liver. Its neck is attenuated and ends in the gastro-hepatic omentum. The cystic duct, into which the neck opens, lies in the gastro-hepatic omentum and is bent at an acute angle to the line of the neck and bladder (fig. 170).

The CYSTIC DUCT is narrow and fibrous, and when it and the neck are laid open the mucous membrane which lines them is seen to be raised into a spiral fold (valve of Heister), keeping the duct open at the bend (fig. 170). The spiral fold or valve and the narrowness of the duct make the passage of even small stones difficult and extremely painful. The nerve supply of the gall-bladder is from the splanchnic nerves, through the solar and hepatic plexuses. The mucous membrane of the gall-bladder shows a curious honeycombed pattern. It contains mucous glands, and is firmly bound by the submucous tissue to the fibro-muscular wall of the bladder. The cystic artery, a branch of the hepatic, crosses the duct and ends on the bladder (fig. 158, p. 76). The vein ends in the portal (fig. 166). The walls of the bile ducts are extremely tough, owing to their strong fibrous sheaths. Their mucous membrane is covered by columnar epithelium.

Blood Supply of the Liver.—The liver is nourished by arterial blood supplied from the cœliac axis by the hepatic artery (fig. 158). The blood conveyed to it by the portal vein passes through the capillary system of the lobules and is poured by the *hepatic* veins into the inferior vena cava as that vessel perforates the diaphragm. They are wide, short trunks, with extremely thin walls. Neither the hepatic veins nor the portal have valves; the steady pressure of the abdominal walls, the respiratory movements of the diaphragm and thorax keep the blood moving from the abdomen towards the heart.

NERVE SUPPLY.—Nerves reach the liver from the great splanchnics, through the solar plexus and the hepatic plexus on the hepatic artery (fig. 175, p. 121).

LYMPHATICS.—Most of the lymphatic vessels pass down in the gastro-hepatic omentum and end in the lymph glands above the head of the pancreas and cœliac axis. They pass through two or three glands in the gastro-hepatic omentum. Lymphatic vessels pass from the upper and posterior surface of the liver into the thorax and end in mediastinal glands. Infections of the liver may spread into the thorax along these lymphatics.

SUBSTANCE OF THE LIVER.—On section the liver presents usually a greyish brown colour and is soft and friable. Scattered here and there are sections of branches of the portal vein, hepatic artery, and bile duct, surrounded by a whitish areolar sheath. This is a tubular prolongation of the capsule of Glisson from the transverse fissure. These structures lie in the *portal canals*, which contain representatives in miniature of all structures which enter the liver through the transverse fissure. Sections of branches of the hepatic veins should be contrasted with, and distinguished from, the sections of the portal vein. The sections of hepatic veins are usually gaping. The veins have thin walls, which are closely applied to the liver substance without any appreciable amount of areolar tissue intervening, and they are unaccompanied by other vessels. The portal veins are collapsed, surrounded by a well-marked areolar sheath, and accompanied by branches of the hepatic artery and bile duct.

THE CONSISTENCE OF THE LIVER DURING LIFE.—It must be remembered that neither the liver hardened *in situ* nor the collapsed organ of the post-mortem room represents the consistence of the liver in life. In life the blood pressure distends the organ and keeps its thin capsule tense; it is soft and friable, and moulded between the diaphragm above and surrounding organs below. Further, it must be kept in mind that the liver moves downwards and forwards with each inspiration; it is never still.

The SPLEEN is now removed for re-examination (p. 87), and a section made across it. Its capsule, which contains non-striated muscle fibres, and the distribution of arteries within it, are to be examined.

DISSECTION VII

THE RETRO-PERITONEAL STRUCTURES OF THE ABDOMEN

The student has finished with the abdominal organs concerned in digestion. There now remain to be examined the structures which lie behind and outside the peritoneum. The pancreas in the adult is also retro-peritoneal, but in the early fœtus, indeed until late in fœtal life, it, like all the other organs of digestion, is covered with peritoneum. The same may be said as regards the second and third stages of the duodenum.

In the present dissection the student is to examine the following structures:

(1) The nerve supply of the abdominal viscera.
(2) The lymphatic system of the abdomen.
(3) The kidneys, ureters, and supra-renal bodies.
(4) The abdominal aorta and branches.
(5) The inferior vena cava and tributaries.
(6) The attachments of the diaphragm, psoas, iliacus and quadratus lumborum.
(7) The lumbar plexus.

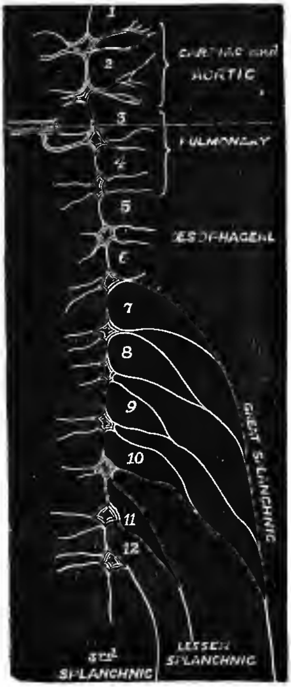
Nerve Supply of the Abdominal Viscera.—Although there is no sense of touch in the abdominal organs, it is hardly necessary to recall evidence that they are closely connected by nerve paths with the central nervous system. These paths occasionally convey painful impressions to the central nervous system. Efferent impulses pass out by them to regulate the blood supply, the secretions and tone of the viscera. These nerve paths are now to be examined. They belong to the sympathetic system, and consist of the following parts:

(1) Rami communicantes.
(2) Sympathetic chain of ganglia.

(3) Splanchnic nerves.
(4) Semilunar ganglia and solar plexus.
(5) Renal ganglia and plexus.
(6) Aortic plexus.
(7) Hypogastric plexus.
(8) The vagi.

Rami Communicantes.—As the dorsal, first and second lumbar spinal nerves emerge at the intervertebral foramina, each is connected with a ganglion of the sympathetic chain by two small nerves — rami communicantes (fig. 120, p. 5). One is white (medullated), and consists of fibres which come out with the nerve roots from the spinal cord. The grey ramus, on the other hand, is outward bound from the ganglion for peripheral distribution in the body and does not concern us here. It is the white rami that form the nerve paths for the viscera. Those for the abdomen come off from the sixth dorsal to the second lumbar nerves, and join the corresponding prevertebral ganglia. The same nerves, it will be noted, supply the skin and muscles of the abdomen, a fact of the greatest practical import. If the dissectors of the thorax have proceeded far enough, the dorsal rami may be examined now (fig. 173).

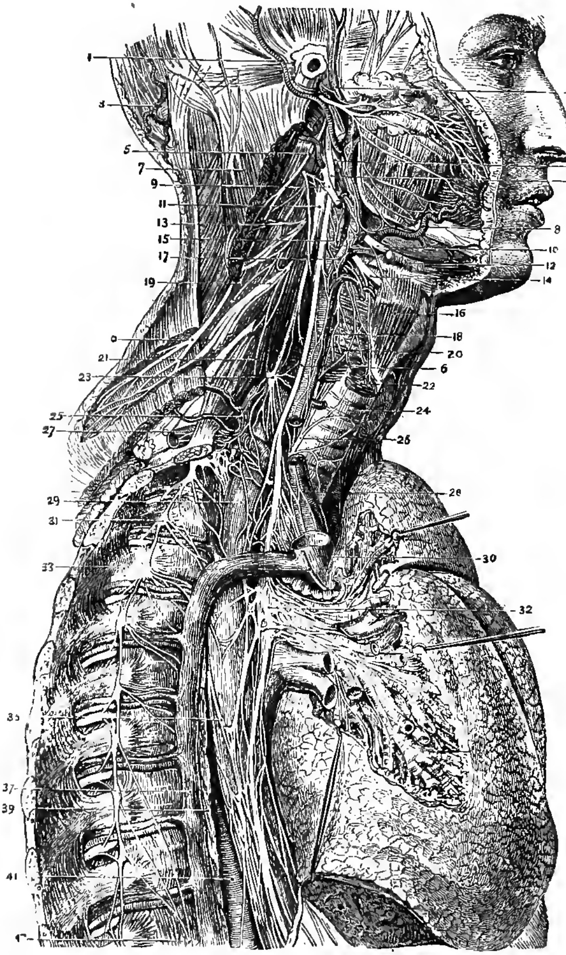
FIG. 173.—DIAGRAM TO SHOW THE ORIGIN OF THE SPLANCHNIC NERVES FOR THE ABDOMEN. (*H. E. Clark.*) (Opposite 3, the communications with one of the dorsal nerves are shown.)



The Sympathetic (Vertebral) Ganglia and Cord. — In the thorax, these lie behind the pleura and over the heads of the ribs (fig. 174, 31). The lumbar ganglia will be found at the inner border of the psoas muscle, behind the vena cava and aorta on the bodies of the vertebræ (fig. 175). Some of them should be found now. There are three or four lumbar ganglia on each side.

The Splanchnic Nerves.—The *great splanchnic nerve* (figs. 173 and 174, 43) is connected with the 5th or 6th to the 10th

Fig. 174.—Showing the course of the splanchnic nerves and vagi in the thorax. (*Hirschfeld and Leveillé.*)



1. Posterior auricular artery. 2. Temporal artery. 3. Occipital artery. 4. Glosso-pharyngeal nerve. 5, 5. Spinal accessory nerve. 6, 6. Pneumogastric nerve. 7. Sterno-mastoid (cut). 8. Facial artery. 9. Hypoglossal nerve, with communication from second cervical nerve. 10. Lower end of ditto. 11. Superior cervical ganglion. 12. Digastricus. 13. Third cervical nerve. 14. Superior laryngeal nerve. 15. Internal carotid. 16. Thyro-hyoid muscle. 17. External carotid. 18. Common carotid. 19. Fourth cervical nerve. 20. Inferior constrictor of pharynx. 21. Phrenic nerve. 22. Crico-thyroid. 23. Middle cervical ganglion. 24. Trachea. 25. Vertebral artery. 26. Recurrent laryngeal. 27. Subclavian artery and annulus of Vicussens. 28. Innominate artery. 29. Œsophagus. 30. Superior vena cava. 31. Second dorsal ganglion. 32. Posterior pulmonary plexus. 33. Phrenic nerve. 35. Vagal plexus on œsophagus. 37. Vena azygos major. 39. Thoracic duct. 41. Descending aorta. 43. Great splanchnic nerve.

dorsal ganglia, and passes down beneath the pleura to the crus of the diaphragm, one on each side. They appear in the abdomen near the outer side of the crura, the fibres of which they perforate as a rule (fig. 175). After a course of an inch within the abdomen, they end in the semilunar ganglia. The right nerve passes behind the inferior vena cava.

The *small* or *lesser splanchnic* nerve connects the 10th and 11th dorsal ganglia with the renal plexus and semilunar ganglion. It passes under the internal arcuate ligament of the diaphragm.

The *smallest* or *least splanchnic* nerve ends in the renal plexus. It comes from the 12th ganglion under the internal arcuate ligament.

The *lumbar splanchnic* nerves pass from the two upper lumbar ganglia to the aortic and hypogastric plexuses (fig. 175). Efferent branches (grey rami) pass from the ganglia to the corresponding lumbar nerve.

Semilunar Ganglia and Solar Plexus (fig. 175).—A semilunar ganglion will be found at each side of the cœliac axis, at the upper border of the pancreas, which should still be in position. The right ganglion lies on the right crus and under the inferior vena cava (fig. 177). The left lies on the left crus, at the inner side of the left supra-renal body. The great and small splanchnic nerves connect the ganglia with the sympathetic chain. Terminal twigs of the right vagus also reach it.

From the ganglia the solar plexus radiates out (fig. 175). The fibres of the plexus end thus:

(1) A great leash passes out to the supra-renal capsule, the medulla of which body arises in common with the sympathetic system (fig. 177).

(2) Fibres pass to the renal plexus and kidney.

(3) Along the cœliac axis and its branches to the liver, stomach, spleen, pancreas and duodenum.

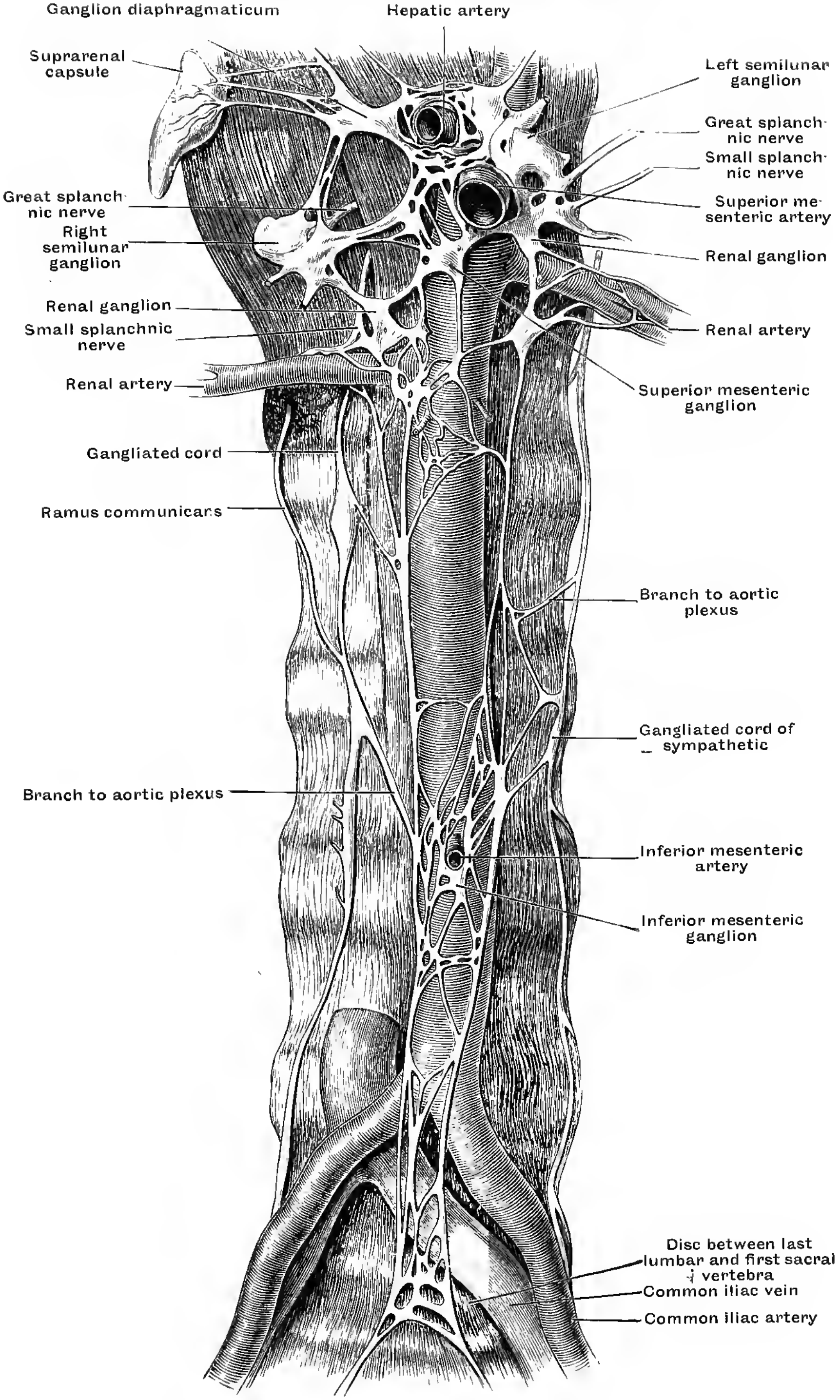
(4) Along the superior mesenteric artery to the bowel.

(5) Along the aorta as the aortic plexus.

(6) Along the inferior phrenic arteries to form the diaphragmatic plexus. A twig from the phrenic joins the right plexus; at the point of union occurs the ganglion diaphragmaticum (fig. 175).

Renal Ganglion and Plexus (fig. 175).—The renal plexus and ganglion on each side lie in front of and above the renal

Fig. 175.—The sympathetic system in the abdomen. (*Henle.*)



vessels. They receive the smallest and a lumbar splanchnic nerve (from the 12th dorsal and 1st lumbar ganglia). The renal plexus is connected with the solar and sends branches on the renal artery to the kidney. If the kidney is pulled on, as in excision, the renal plexus and through it the solar plexus are also strained.

Aortic Plexus (fig. 175).—The aortic plexus lies on the aorta. It is derived from the solar plexus and lumbar splanchnics. It gives off the spermatic plexus along the spermatic artery to the testicle and along the ovarian to the ovary; fibres also pass out on the lumbar arteries. The inferior mesenteric plexus issues from it.

Hypogastric Plexus (fig. 175).—The hypogastric plexus will be found beneath the peritoneum on the bifurcation of the abdominal aorta and over the promontory of the sacrum. Nerves pass from it to the rectum by branches of the inferior mesenteric artery. The plexus contains a ganglion, and divides into right and left halves, which pass to the pelvic plexus on each side. The hypogastric plexus is formed from the aortic plexus and lumbar splanchnics.

The Vagi.—The two vagi connect the stomach with the medulla oblongata. They have already been seen on the anterior (left) and posterior (right) surfaces of the stomach. The right vagus sends terminal branches to the solar plexus. Their course in the thorax is shown in fig. 174.

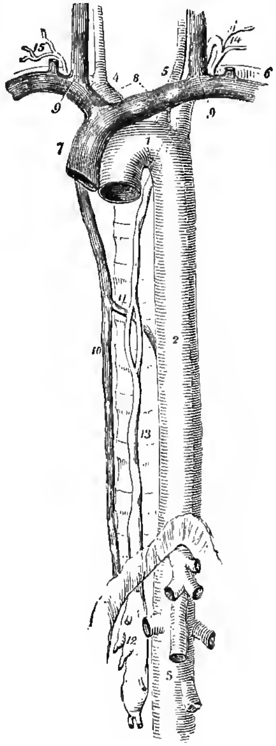
The Lymphatic System of the Abdominal Cavity.—This system is intimately connected with the pathology of many abdominal diseases, and should be studied now; otherwise, in dissecting the aorta and vena cava, the glands and vessels will be cut away unnoticed in the connective tissue surrounding them. It is made up of the following parts:

(1) The *receptaculum chyli* (fig. 176, 12), the lower end of the thoracic duct, to which, with the exception of the superior hepatic vessels, all the lymph channels of the abdominal viscera pass. It is found by separating widely the right crus of the diaphragm from the aorta, between which it is hid. The right crus may be cut through if necessary. It rests on the 1st lumbar vertebra and on the vertebra above and below it. It is frequently bifid and always thin-walled and collapsed. It may be mistaken for the right azygos vein which lies near it.

(2) The *cœliac* and *superior mesenteric* groups of glands lie

at the upper and lower border of the pancreas and round the formation of the portal vein. The lymphatics from the small intestine (lacteals), great intestine, the stomach, duodenum, liver, pancreas and spleen end in these glands. From the glands several trunks pass backwards to the receptaculum chyli. The mesenteric glands and those situated in the omenta of the stomach and mesentery of the great gut and rectum have been already examined. The lymph vessels, it should be remembered, accompany the veins; the nerves go with the arteries.

Fig. 176.—The course of the thoracic duct. (*Wilson.*)



(3) The *lumbar glands* lie along the inner border of the psoas muscle on each side of the great blood-vessels. Some are found in front of the inferior vena cava. They receive the lymph from the pelvis, abdominal walls, and, through the iliac glands, from the lower extremities. The efferent vessels from the right and left lumbar glands form the right and left *lumbar lymphatic ducts.* These unite to form the receptaculum chyli.

(4) The *iliac glands.* Three or four lie above Poupart's ligament, on each side of the external iliac vessels. A chain lies along the outer side of the external and common iliac vessels. This chain receives the lymph from the lower extremities and from the *internal* iliac set of glands on the lateral wall of the pelvis near the commencement of

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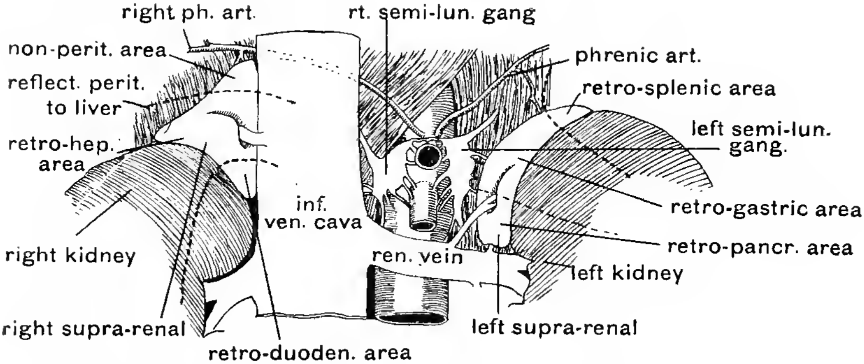
1. Arch of the aorta. 2. Thoracic aorta. 3. Abdominal aorta, showing its principal branches divided near their origin. 4. Arteria innominata, dividing into right carotid and right subclavian. 5. Left carotid. 6. Left subclavian. 7. Superior cava, formed by the union of (8) the two venæ innominatæ; and these by the junction (9) of the internal jugular and subclavian vein at each side. 10. Greater vena azygos. 11. Termination of the lesser in the greater vena azygos. 12. Receptaculum chyli; several lymphatic trunks are seen opening into it. 13. Thoracic duct, dividing opposite the middle of the dorsal vertebræ into two branches which reunite; the course of the duct behind the arch of the aorta and left subclavian artery is shown by a dotted line. 14. The duct making its turn at the root of the neck and receiving several lymphatic trunks previously to terminating in the posterior aspect of the junction of the internal jugular and subclavian vein. 15. Termination of the trunk of the ductus lymphaticus dexter.

the internal iliac artery. Their efferent vessels pass to the lumbar glands.

Supra-renal Bodies (Adrenals, Supra-renal Capsules).—The supra-renal bodies are intimately connected with the solar plexus of the sympathetic system. The student has already seen a great leash of nerves enter each of them. Each body caps the upper pole of the kidney on its inner and anterior aspect. The right is pyramidal, the left is crescentic, its inner end reaching downwards to the hilum and vessels of the kidney (fig. 177). They are easily detached from the kidney, and are not dislocated with that organ. Their function is not yet thoroughly understood; they are ductless glands; one form of disease gives rise to a pigmentation of the skin. It will be evident from their rich nerve and blood supply that their function is not one of small import.

Fig. 177.—Diagram of the position and relationships of the supra-renal bodies.



Relationships of the Right Body (fig. 177).—It lies behind the liver, its apex projecting within the retro-hepatic non-peritoneal area (fig. 171). It lies by the side of, and may pass behind, the inferior vena cava (fig. 177). Its concave base rests on the apex and inner side of the kidney. Behind it are the right crus and great splanchnic nerve. The peritoneum covering the anterior surface of the kidney extends upwards some way on its anterior aspect, and is then reflected to the liver (fig. 177).

Relationships of the Left Body.—The posterior wall of the lesser sac of the peritoneum covers the greater part of its anterior aspect (fig. 153, p. 67). The spleen, and occasionally the tail of the pancreas, lies in front of it, the area between these two being in contact with the posterior aspect of the stomach (fig. 177). It lies on the left crus and great splanchnic nerve; the left semilunar ganglion is situated between it and the aorta.

Blood Supply (fig. 182).—ARTERIES. (1) From the phrenic; (2) from the aorta; (3) from the renal.

VEINS.—There are also three veins: those on the right side join the inferior vena cava; those on the left the renal. The veins emerge from a hilum on its anterior aspect; the nerves and arteries enter chiefly at a fissure on its concave renal aspect.

STRUCTURE.—A section through a body shows the yellow coloured cortex and the deep maroon medulla in the centre. The cortex forms the larger part of the gland. A thin fibrous capsule and much loose areolar tissue surrounds each body.

THE KIDNEYS

The kidneys lie obliquely one on each side of the vertebral column, opposite the twelfth dorsal and first and second lumbar vertebrae. The long axis of each kidney is directed downwards, outwards, and slightly forwards (fig. 117, p. 2). Their lower poles are further apart than their upper. The anterior surface, it should be noted, looks outwards almost as much as forwards; their posterior surface almost as much inwards as backwards.

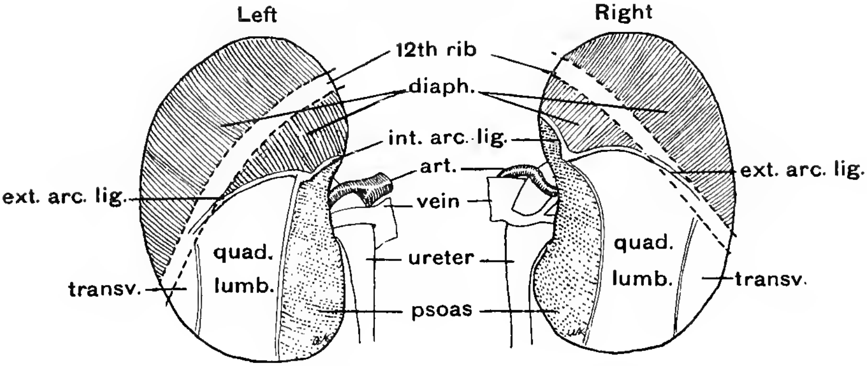
The kidneys were already exposed from behind in the lumbar region (p. 9). The twelfth rib was seen to descend obliquely behind and separate the upper and outer third from the lower and inner two thirds (fig. 178). The *convex* margin appeared at the outer border of the quadratus lumborum.

Relationship to the Surface of the Body.—The anterior aspects of the kidneys are so deeply placed that they can be only obscurely palpated on the anterior aspect of the abdomen (fig. 168, p. 104). The right kidney lies behind the liver, costal margin, colon and duodenum; the left behind the spleen, stomach, costal margin, colon and small gut. The lower pole of the kidney reaches to an inch above the level of the umbilicus. When the finger is placed on the abdomen, internal to the ninth costal cartilage, it lies over the hilum of the kidney. Owing to the pressure of the liver, the right kidney lies rather lower than the left. The lower part and pole of the kidney can be palpated in the lumbar region, in the angle between the last rib and erector spinæ (fig. 117, p. 2).

Fixation of the Kidneys.—The right kidney is often displaced; it may become movable and give rise to great distress. The left kidney is seldom affected. It is therefore necessary to consider now the structures which keep the kidneys fixed. They are:

(1) The *peritoneum* covering its anterior surface (see fig. 153, p. 67). Neither kidney is covered completely (figs. 178, 179). The duodenum covers the inner part of the right kidney; on to it the peritoneum is reflected. The meso-colon is attached to the anterior surface (fig. 179). The part of the kidney above this attachment is covered by the *supra-colic peritoneum*; the part below by the *infra-colic peritoneum*. The tail of the pancreas, the attachments of the lieno-renal ligament and meso-colon, are on the anterior aspect of the *left* kidney; its peritoneal covering is thus divided into three areas; one of them being part of the lesser sac (fig. 179).

FIG. 178.—DIAGRAM OF THE POSTERIOR RELATIONSHIPS OF THE RIGHT AND OF THE LEFT KIDNEY.



(2) The *perirenal capsule*. The kidney lies in a bed of connective tissue, commonly laden with fat. The capsule thus formed is continuous with the connective tissue of the diaphragm, the pancreas, vena cava and aorta.

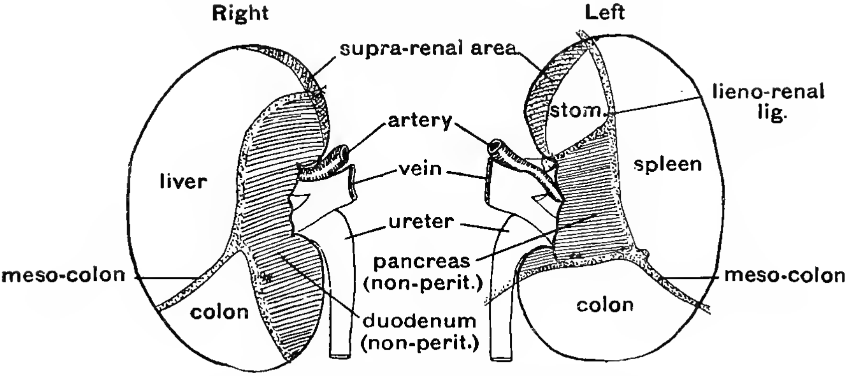
(3) The renal artery, vein, and nerves. These form a pedicle which binds the kidney to the aorta, vena cava, and solar plexus.

(4) The abdominal walls. These keep the kidneys in place

by pressing the other viscera against them. Pressure on the liver above, as from corsets, commonly forces the right kidney downwards, but under certain conditions it may displace it upwards. In women the lower pole of the right kidney, instead of being an inch above the crest of the ilium, may lie in the iliac fossa. The upper third of the kidney lies on the diaphragm; hence the kidney undergoes a slight respiratory movement (fig. 185A, p. 146).

Relationships.—These have already been incidentally considered. The anterior relationships will be seen from fig. 179; the posterior relationships, which were examined in the lumbar dissection, from fig. 178. The kidneys should be lifted forwards, and the structures in contact with their posterior surfaces again examined. The twelfth rib divides the posterior surface into supra- and infra-costal areas (fig. 178). The supra-costal area is in contact with the diaphragm, internal and external arcuate ligaments (fig. 185A, p. 146). The infra-costal area lies against the psoas on its inner part, and the quadratus lumborum and part of the transversalis on its outer part. The twelfth dorsal nerve, ilio-hypogastric, ilio-inguinal, the first and sometimes the second lumbar vessels pass outwards behind the infra-costal part (fig. 184).

FIG. 179.—DIAGRAM OF THE ANTERIOR RELATIONSHIPS OF THE RIGHT AND LEFT KIDNEY. The unshaded areas are covered by peritoneum.



Blood Supply.—ARTERIES. The renal arteries arise from the aorta and pass transversely outwards (fig. 182). Accessory renal vessels are frequently present. The right renal artery passes behind the vena cava. Each renal artery divides, as it reaches the hilum of its kidney, into a number of branches; most pass in front of the ureter, but one or two pass behind it. Each renal artery supplies a branch to the supra-renal capsule of the same side, and branches which end in the perirenal capsule and communicate with branches of the lumbar arteries in the sub-peritoneal plexus.

VEINS.—The renal veins join the inferior vena cava, the right vein being much shorter than the left. They lie in front of the arteries. The main branches of the vein emerge in front of the arteries, but some emerge also as the most posterior structures in the hilum. The left vein receives the supra-renal and spermatic veins. The veins in the perirenal capsule communicate with the spermatic supra-renal and veins in the cortex, and end in the renal veins. The renal veins are connected on each side by a branch with the azygos veins. At a very early fœtal stage the renal veins end in the azygos or cardinal veins.

NERVES.—The nerves have already been traced from the renal plexus; they enter on the arteries (fig. 175).

LYMPHATICS.—The lymphatic vessels pass to the lumbar glands.

Structures in the Hilum.—A kidney is removed from the body for examination, an inch of the ureter being left attached. In the hilum, the entrance to the SINUS of the kidney, the structures will be seen to be arranged thus from back to front: (1) The main branches of the renal vein; (2) the main branches of the renal artery; (3) the pelvis of the kidney; (4) small branches of the renal artery; (5) small branches of the renal vein. The structures are surrounded by connective tissue and fat. The small vessels behind are liable to injury in the removal of calculi from the pelvis of the kidney.

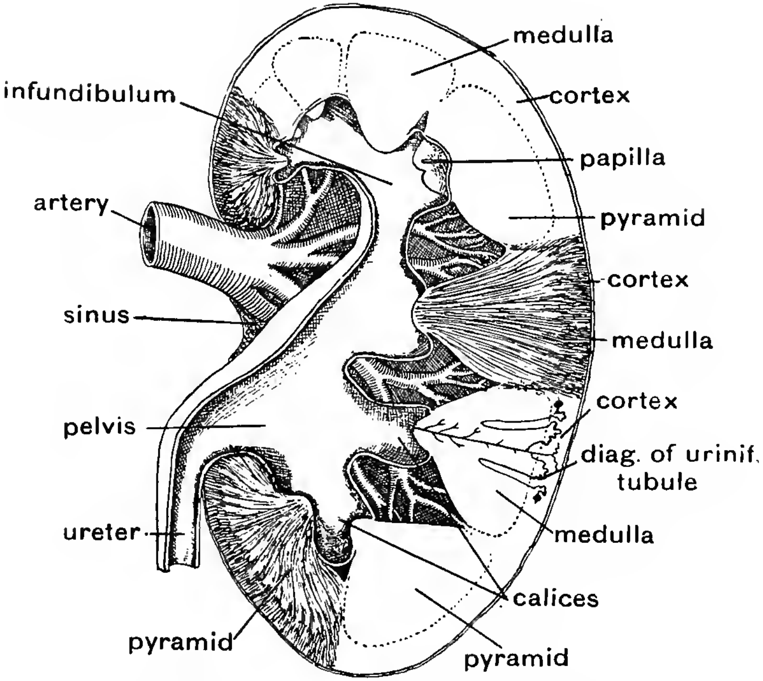
Section of the Kidney (fig. 180).—A kidney is laid open by a section passing in along its convex margin and brought out at the hilum, so as to lay open the pelvis of the kidney and commencement of the ureter. The student should try to form a true conception of the course of the urine from its point of secretion until it reaches the ureter. The following points are to be noted:

(1) The *renal capsule.* The renal substance is enclosed in a thin tough capsule, which is only bound to the intra-renal connective tissue by fine fibres, and therefore easily stripped off.

In some forms of disease (cirrhosis) this is not possible. The capsule is firmly adherent to the pelvis of the kidney at its attachment within the sinus.

(2) The *cortex*. One third of the depth of the normal kidney, as now seen in section, is made up of cortex. In the cortex are contained the renal glomeruli, the convoluted tubules, and cortical arteries and veins (fig. 181). The cortex dips in between the pyramids and separates their bases.

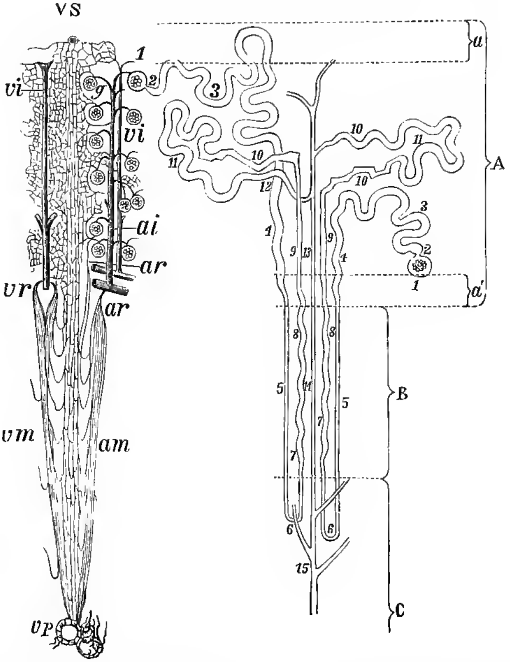
FIG. 180.—A DIAGRAMMATIC SECTION OF THE PYRAMIDS AND PELVIS OF THE RIGHT KIDNEY, VIEWED FROM BEHIND.



(3) The *medulla*. The loop tubules, straight, collecting and excretory tubules, are gathered into smooth medullary pyramids (see fig. 181). There are from twelve to fifteen of them; their bases project towards the cortex. The apices of the pyramids form conical eminences round the sinus. They project into the pelvis of the kidney, its lining membrane covering them. On the apices open the excretory tubules, which pour the urine into the pelvis of the kidney (fig. 181).

(4) The vessels which enter at the hilum pass towards the cortex between the medullary pyramids. Near the bases of the pyramids they form arches, from which cortical and recurrent (medullary) vessels spring (fig. 181).

Fig. 181.—Scheme of the renal tubules and vessels.
(*Wilson; modified from Klein.*)



On the left of the figure the arrangement of the blood-vessels of the kidney is shown, on the right the course of the uriniferous tubules.

vs. Venæ stellatæ of Verheyen. *vi.* Interlobular veins. *vr.* Venæ rectæ. *vm.* Veins of medullary part. *vp.* Veins of papillæ. *ai.* Interlobular artery. *g.* Glomerulus. *ar.* Arteriæ rectæ. *am.* Arteries of medullary part. A. Cortex. B. Boundary zone. C. Papillary zone of medulla. *a, a'.* Superficial and deep layers of cortex, free of glomeruli. 1. Malpighian capsule. 2. Neck. 3. First convoluted tubule. 4. Spiral tubule of Schachowa. 5. Descending limb of looped tubule of Henle. 6. Bend. 7, 8, 9. Ascending limb. 10. Irregular tubule. 11. Second convoluted tubule. 12. Junctional tubule. 13, 14. Collecting tubule. 15. Excretory tubule.

(5) The *pelvis of the kidney* (fig. 180). The pelvis of the kidney is the trumpet-shaped dilatation of the ureter within the sinus of the kidney and emerges at the hilum. In it renal calculi are apt to form. If small, they pass down the ureter, causing renal colic; but they may grow until they form an accurate cast of the cavity. The pelvis shows two or three divisions; to these the name of infundibula is given (fig. 180). The minor diverticula of the infundibula, into which the apices

of the pyramids project, are called calices (fig. 180). The pelvis shows mucous, submucous, muscular and fibrous coats. Its mucous membrane is covered by transitional stratified epithelium. The hilum of the right kidney lies behind the duodenum and in front of the psoas muscle, at the level of the transverse process of the first lumbar vertebra. The pancreas lies in front of the hilum of the left kidney.

The Ureter.—The course of the urine from the pelvis of the kidney to the bladder is now to be traced. It passes down by the ureter, a narrow tube fourteen to sixteen inches long with a muscular coat, covered externally by fibrous tissue and lined by mucous and submucous coats. The ureter passes down to the pelvis in the loose sub-peritoneal tissue. Its blood supply is derived from renal, spermatic and iliac vessels. It receives its nerves from the renal and pelvic plexuses.

COURSE.—The course of the ureter presents two distinct stages—*abdominal* and *pelvic*. The abdominal stage is alike in both sexes; the pelvic stage differs.

The *abdominal stage* (fig. 182) extends from the hilum of the kidney to the brim of the pelvis, which the ureter crosses at the bifurcation of the common iliac artery.

This stage lies behind the peritoneum; coils of small gut lie in front of it; the termination of the ileum (right side), the commencement of the rectum (left side), cross it above the brim. The ureter lies on the psoas muscle. The genito-crural nerve emerges behind it; the spermatic or ovarian vessels cross in front of it (fig. 182). As it leaves the kidney it lies behind the duodenum on the right side and tail of the pancreas on the left.

PELVIC STAGE.—(1) *In the male* (fig. 207, p. 185). The course of the ureter is not to be dissected out in the pelvis now, but by pulling on it the leading features of its course may be followed. The pelvic stage is subdivided into two in the male:

(*a*) On the internal iliac artery and beneath the peritoneum;

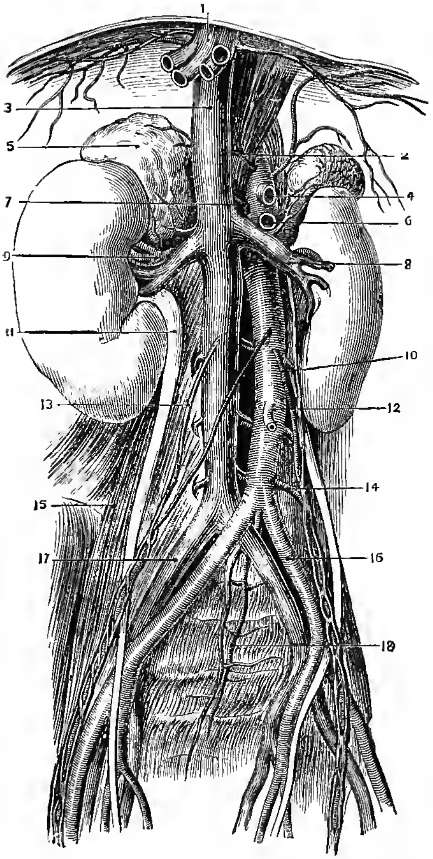
(*b*) In the posterior false ligament of the bladder and connective tissue between the base of the bladder and rectum. The vas deferens crosses it in the second of the two pelvic stages.

(2) *In the female.* Three sub-stages are recognised in the pelvic course of the ureter:

(*a*) As in the male.

(*b*) In the connective tissue in the base of the broad ligament and near the neck of the uterus. The uterine artery loops over it. In this stage the ureter is liable to injury in operation on the uterus (fig. 197, p. 170).

FIG. 182.—ABDOMINAL AORTA AND VENA CAVA. (*Henle.*)



1. Hepatic vein (cut). 2. Phrenic arteries. 3. Vena cava. 4. Cœliac axis (cut). 5. Suprarenal capsule. 6. Superior mesenteric artery (cut). 7. Suprarenal artery. 8. Renal vein. 9. Renal artery. 10. Left spermatic vessels. 11. Right ureter. 12. Inferior mesenteric artery. 13. Right spermatic vein. 14. A lumbar artery. 15. Psoas magnus. 16. Common iliac artery. 17. Common iliac vein. 18. Middle sacral artery.

(*c*) In the connective tissue between the side and roof of the vagina and base of the bladder. This stage can be palpated from the vagina.

The oblique valvular entrance of the ureter to the bladder will be seen later.

Abdominal Aorta and Inferior Vena Cava (fig. 182).—The two great vessels in the retro-peritoneal region of the abdomen are now to be examined—the abdominal aorta and inferior vena cava. Through the abdominal aorta the abdomen and lower extremities are supplied with blood, and through the inferior vena cava the same blood is returned to the heart. But there is this difference: all the blood supplied to the organs concerned in the digestion and absorption of food is returned to the inferior vena cava through the liver, and enters by the hepatic veins. Hence there is a discrepancy between the ramification of the aorta and its accompanying venous trunk. These blood-vessels and their branches require much cleaning. The lumbar ganglia of the sympathetic chain should be noted; the lumbar lymphatic glands, the solar and aortic plexuses, pancreas and peritoneum cleaned away (fig. 184).

Abdominal Aorta.—The abdominal aorta commences at the aortic opening in the diaphragm (fig. 182), opposite the body of the twelfth dorsal vertebra, and is directly continuous with the thoracic aorta. It extends downwards to the front of the fourth lumbar vertebra, where, a little to the left of the middle line, it bifurcates into the two common iliac arteries. This point of bifurcation lies a little to the left of the middle point of a line drawn across the front of the abdomen between the highest points of the iliac crest, and usually corresponds to a point a little below and to the left side of the umbilicus.

RELATIONSHIPS.—*Behind.* The aorta lies on the lumbar vertebræ, the anterior common ligament and left lumbar veins. The commencement of the thoracic duct lies behind and to its right side.

In front of the aorta are the stomach, liver, greater and lesser omenta, transverse colon, and coils of jejunum and ileum; while lying successively on the surface of the aorta are the solar plexus, pancreas and splenic vein, third part of the duodenum, left renal vein, mesentery, peritoneum and aortic plexus (fig. 175).

Laterally, the aorta is related at first to the crura of the diaphragm, the vena azygos major and thoracic duct intervening between the aorta and right crus. Beyond the crura, the inferior vena cava lies to the right, and the left sympathetic cord on the left side of the artery. Some lumbar lymphatic glands lie close to the aorta.

BRANCHES.—Three sets of branches are given off from the abdominal aorta:

(1) *Visceral for alimentary system.* They are unpaired.
    a. Cœliac axis; *b.* Superior mesenteric; *c.* Inferior mesenteric.

(2) *Visceral for uro-genital organs.* They are paired.
    a. Supra-renal; *b.* Renal; *c.* Spermatic or ovarian.

(3) *Parietal for walls of the abdomen and spine.* They are paired.
    a. Phrenic; *b.* Lumbar (four pairs); *c.* Middle sacral.

The distribution of the visceral branches has already been examined (p. 95); the student should now mark their points of origin.

The SPERMATIC ARTERIES (fig. 182, 10), which were seen passing to the testicle by the inguinal canal, arise below the renals and pass down behind the peritoneum. The ovarian arteries represent them in the female.

Parietal Branches.—(1) The *inferior phrenic arteries* (fig. 182, 2), two in number, are given off from the front of the aorta as it lies between the pillars of the diaphragm. Each artery passes outwards on the abdominal surface of the diaphragm, on which it ramifies. The right artery passes behind the vena cava, the left behind the œsophagus (fig. 177, p. 124). Each artery divides into an anterior and a posterior branch. The *anterior* branches incline forwards and, anastomosing together, form an arch underneath the anterior part of the diaphragm. The *posterior* branches arch backwards and outwards, and anastomose with the lower intercostal arteries. Each artery gives off *superior capsular* branches to the supra-renal body.

The phrenic veins open into the inferior vena cava.

(2) The *lumbar arteries* are five in number on each side, the last pair being given off from the middle sacral artery (fig. 232, p. 231). Each artery passes outwards over the corresponding body of a vertebra, and underneath the gangliated cord of the sympathetic and psoas muscle. The first two arteries pass behind the crura of the diaphragm; the right arteries pass also behind the inferior vena cava. They then course outwards behind the quadratus lumborum (the first usually in front of that muscle) and run forwards in the abdominal wall between the transversalis and internal oblique muscles. They terminate within the sheath of the rectus muscle by anastomosing with the epigastric arteries (fig. 140, p. 39). Each artery, like an intercostal artery, gives off a dorsal and lateral branch (fig. 231, p. 228). The *dorsal* branch is given off underneath the psoas, and, having supplied a spinal twig through the intervertebral foramen to the spinal canal and cord, it passes backwards between the transverse processes to supply the muscles of the back.

The lumbar veins enter the inferior vena cava, those of the left side passing behind the aorta.

(3) The *middle sacral artery* arises from the posterior surface of the aorta, a short distance above the bifurcation (fig. 203, p. 179). It passes beneath the left common iliac vein, lying

on the fifth lumbar vertebra and sacral promontory. It courses down on the front of the sacrum as far as the front of the coccyx, where it gives branches to the coccygeal body and anastomoses with the lateral sacral arteries. The fifth lumbar arteries are usually derived from the commencement of the middle sacral artery.

The *middle sacral vein* enters the left common iliac vein.

Common Iliac Arteries (fig. 182).—Each common iliac artery extends from the bifurcation of the aorta to a point opposite the lower border of the fifth lumbar intervertebral disc, where it divides into external and internal iliac arteries. The right artery is rather longer than the left, owing to the aorta lying towards the left side of the spinal column. Each artery is covered in front by peritoneum and intestines. They are crossed by branches of the sympathetic cord to the hypogastric plexus, and at their terminations by the ureter (fig. 175). The left artery is crossed, in addition, by the superior hæmorrhoidal artery. The commencement of the rectum crosses the left, the termination of the ileum the right. Each artery lies on the vertebral column and gangliated cord of the sympathetic. The right artery lies also upon the right and left common iliac veins as they unite to form the inferior vena cava. Usually no branch arises from the common iliac trunks.

Surface Markings.—A line drawn from a point $\frac{3}{4}$ inch below and to the left of the umbilicus, to a point on Poupart's ligament half an inch internal to its mid-point, indicates the course of the common and external iliac arteries on the surface of the abdomen. The upper third of the line lies over the common iliac artery. The artery lies under the peritoneum to the outer side of its vein, and presents little difficulty in operations to tie it.

External Iliac Artery.—The external iliac artery extends from the bifurcation of the common iliac artery to a point half an inch internal to the middle of Poupart's ligament, where it passes under that structure to enter Scarpa's triangle as the femoral artery.

Relations (fig. 203, p. 179).—It lies at first above the brim of the pelvis, along the inner side of the psoas muscle and its fascia. Near its termination it rests on the surface of the psoas. The artery is covered superficially by peritoneum, which separates it on the right side from coils of the ileum and on the left side from the sigmoid flexure. The spermatic vessels and genito-crural nerve lie to its outer side. It is crossed near its termination by the genital branch of the genito-crural nerve and the deep circumflex iliac vein; in the male by the vas deferens, and in the female by the ovarian vessels and round ligament of the uterus. The external iliac vein lies internal to the artery, and on the right side passes behind it at its upper part. The iliac chain of lymphatic glands lies along the outer side of the common and external iliac vessels. Just above Poupart's ligament there are three large glands which receive lymph from the abdominal wall and inguinal glands. They lie on the external iliac vessels. The innermost of the three may lie partly in the femoral ring. Lymph from the lower extremity passes along the iliac chain of glands, and hence these enlarge in inflammatory affections of that part.

BRANCHES.—They are two in number and arise from the artery at the upper border of Poupart's ligament: (1) Deep epigastric; (2) deep circumflex iliac. These have been already examined (p. 40).

Iliac Veins.—The *external iliac vein* (fig. 203, p. 179) is the continuation upwards of the common femoral. It receives the deep epigastric veins (venæ comites) and deep circumflex iliac, and passes up on the inner side of the artery lying on the brim of the pelvis and sometimes depressed within it. The right vein gradually passes deep to its artery, for the inferior vena cava is formed beneath the right common iliac. Opposite the sacro-iliac articulation it is joined by the internal iliac to form the common iliac vein.

The *common iliac veins* (fig. 203, p. 179) pass upwards and inwards, converging to a point opposite the right side of the fifth lumbar vertebra, where they unite to form the inferior vena cava. The left vein lies to the right side of the left common iliac artery, and then passes under the artery of the right side. The right vein lies under the artery of the same side. The common iliac veins receive the *ilio-lumbar* veins, the vein of the left side receiving in addition the *middle sacral* vein.

Inferior Vena Cava (fig. 182).—COURSE. The *inferior vena cava* commences by the junction of the two common iliac veins on the right side of the fifth lumbar vertebra. It ascends on the right side of the aorta as far as the third lumbar vertebra, where it becomes separated from the aorta by the right crus of the diaphragm. It then passes upwards and forwards on the diaphragm in a deep groove on the posterior surface of the liver, and enters the thorax by piercing the central tendon of the diaphragm (fig. 185A). It is fixed firmly to its rigid foramen in the diaphragm. Its termination in the right auricle will be seen in the dissection of the thorax.

Relations.—*In front*, from above downwards, there lie: (1) The liver; (2) foramen of Winslow; (3) the second stage of duodenum and commencement of the third, head of pancreas, and commencement of portal vein; (4) peritoneum and attachment of mesentery; (5) the spermatic artery; (6) the right common iliac artery.

Behind: (1) The diaphragm and right crus; (2) right splanchnic nerves and sympathetic chain (fig. 177, p. 124); (3) right lumbar arteries; (4) right renal artery; (5) the lumbar vertebræ and ligaments and origin of the right psoas muscle.

In diseased conditions, the right kidney and supra-renal capsule may adhere to the inferior vena cava; their removal may then lead to its rupture.

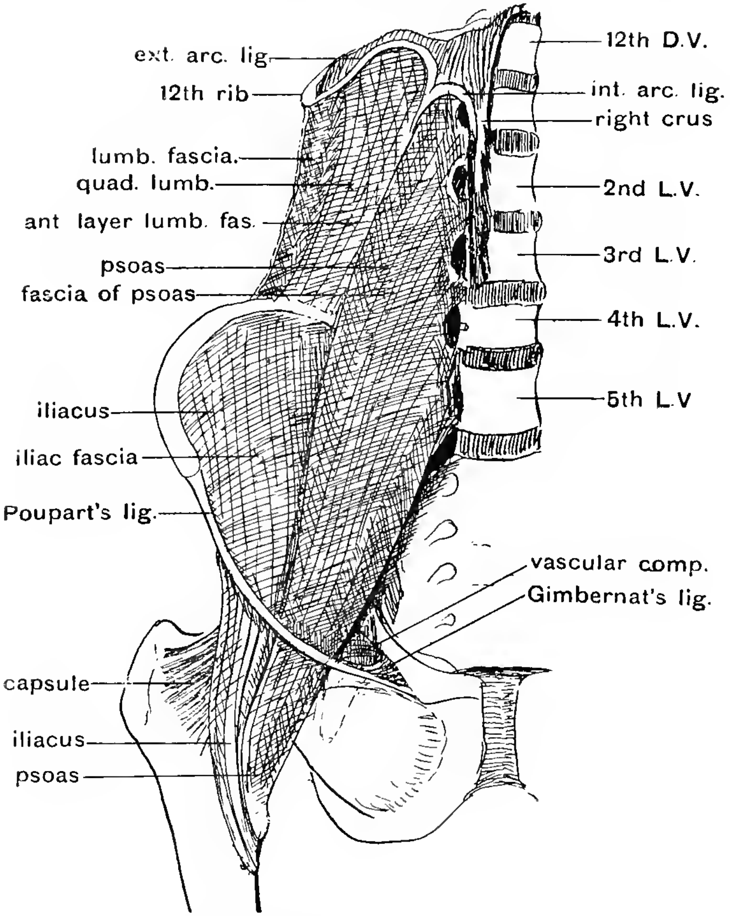
Tributaries.—These have been already examined. From above downwards they are:

(1) The ductus venosus in the fœtus.
(2) The hepatic veins.
(3) The right supra-renal.
(4) The phrenic.
(5) The renal.
(6) The right spermatic and ovarian.
(7) The lumbar veins.

Muscles and Fasciæ of the Posterior Abdominal Wall.—There are four muscles in the posterior abdominal wall: (1) the iliacus, (2) the psoas, (3) the quadratus lumborum, and (4) the vertebral and arcuate origins of the diaphragm (fig. 183). Each of these muscles, like the other muscles of the body, has a sheath or capsule. To these sheaths special names have been given. That of the iliacus is named the iliac fascia; that of the psoas, the psoas fascia, which by many is described as part of the iliac fascia. That of the quadratus lumborum forms the anterior and middle layer of the lumbar fascia (fig. 118, p. 3); that of the diaphragm has had no special name given to it, nor does it need one. A sheath only surrounds the free and unattached part of a muscle; hence the attachments of the fasciæ are determined by the attachments of the muscles.

The importance of these fasciæ is purely surgical. The student will see, by looking at his part, that an abscess forming in the lumbar vertebræ, as is occasionally the case, may find its way down the tubular sheath of the psoas muscle beneath Poupart's ligament into the thigh.

FIG. 183.—THE MUSCLES AND FASCIÆ ON THE POSTERIOR WALL OF THE ABDOMEN. (*Diagrammatic.*)



The *fascia of the psoas* covers that muscle and is attached internally to the front of the spine and fibrous arches of the psoas muscle as far down as the upper part of the sacrum, where the attachment extends along the ala of the sacrum and ilio-pectineal line. Superiorly it forms a thickened band, the *ligamentum arcuatum internum* (fig. 183), from which fibres of the diaphragm take origin. *Externally* it becomes continuous with the fascia of the quadratus lumborum and the fascia of the iliacus. The fascia of the quadratus is thickened superiorly to form the *ligamentum arcuatum externum,* and is continuous below with the ilio-lumbar ligament.

The *fascia of the iliacus* is continuous with the fascia of the psoas, and is attached above and externally to the crest of the ilium and the outer half of Poupart's ligament. Beneath the inner half of Poupart's ligament, the combined fasciæ of the iliacus and psoas pass downwards to form with the fascia transversalis the femoral sheath (Pl. XL). The disposition and attachment of this fascia readily explain why the pus in a lumbar abscess extends into the iliac fossa and then travels behind Poupart's ligament into the thigh, but is effectually prevented from entering the pelvis, by the attachment of the fascia to the brim of that cavity.

Quadratus Lumborum (fig. 183).—ORIGIN. From the posterior third of the inner lip of the crest of the ilium and the ilio-lumbar ligament. A few fibres on the anterior surface of muscle arise from the transverse processes of the third, fourth, and fifth lumbar vertebræ.

INSERTION.—To the lower border of the last rib and the transverse processes of the upper four lumbar vertebræ.

The muscle belongs to the intercostal series, and contains three sets of fibres, named according to their attachments: (1) Ilio-costal, (2) ilio-transverse, (3) costo-transverse. The tips of the lumbar transverse processes represent ribs.

NERVE SUPPLY.—Anterior divisions of the twelfth dorsal, first and second lumbar nerves.

ACTION.—It depresses and stays the last rib, thus giving a firm basis for the action of the lower costal origin of the diaphragm. It is a muscle of inspiration. It also acts as a lateral flexor of the spine.

RELATIONS.—The outer margin and part of the posterior aspect of this muscle were exposed in the lumbar dissection (p. 7). In front of it lies the outer part of the infra-costal area of the kidney, the ascending and descending colon, and the peritoneum reflected from the meso-colon. The external arcuate ligament bridges over its costal attachment.

Ilio-psoas.—This is formed by two muscles which are distinct at their origin, but become fused below near their insertion (fig. 183).

Iliacus.—ORIGIN. From the iliac fossa and ala of the sacrum.

INSERTION.—Into a depressed surface below and external to the lesser trochanter of the femur, and partly into the tendon of the psoas.

The iliac fascia covers it. On it rest the cæcum and appendix on the right side, and the sigmoid colon on the left. The external cutaneous nerve crosses it, and the anterior crural nerve emerges between it and the psoas.

Psoas Magnus.—ORIGIN. (1) From the intervertebral discs and contiguous margins of the bodies of the vertebræ, extending from the twelfth dorsal to the fifth lumbar; (2) from the fibrous arches which stretch over the lumbar arteries as they lie on the sides of the bodies of the vertebræ, and (3) by fleshy slips from the anterior aspects of the transverse processes of the lumbar vertebræ.

INSERTION.—By a strong tendon into the lesser trochanter of the femur (see p. 198, Part I).

The *psoas parvus* muscle (fig. 184, 4) lies in front of the psoas magnus, and is more frequently absent than present. It is a vestigial muscle. When present it arises from the bodies of the last dorsal and first lumbar vertebræ, and is inserted by a long tendon into the ilio-pectineal line. The tendon at its insertion spreads over the brim of the pelvis in front, fusing with a tough fibrous ligament behind the ilio-pectineal eminence which may be used by surgeons to close the femoral ring.

NERVE SUPPLY.—From the second and third lumbar nerves. The twigs for the psoas come off within the muscle; those for the iliacus spring from the anterior crural nerve.

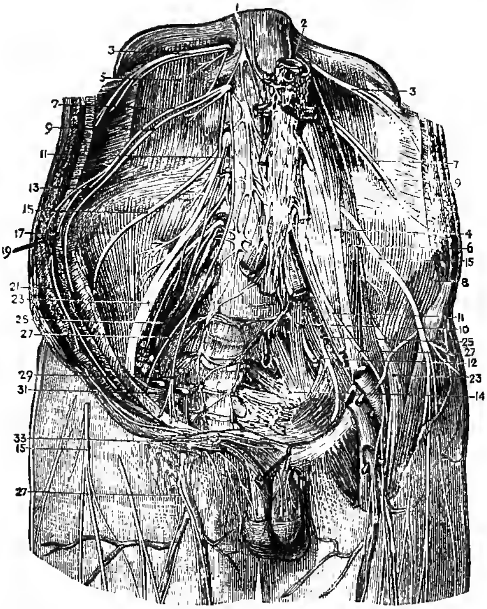
ACTION.—The ilio-psoas acts on the thigh, flexing and rotating it outwards. If the thigh is fixed, it flexes the pelvis and spine forwards. If the cæcum, appendix, or kidney is diseased, the pressure of the contracting muscles may elicit pain in them. In hip-joint disease the muscle is contracted, approximating the origin and insertion of the muscle. Hence, if the thigh be forcibly extended, the lumbar region of the spine is rendered more convex forwards.

RELATIONSHIP TO NERVES (fig. 184).—(*a*) Close to the inner edge of the muscle on the bodies of vertebræ is the gangliated cord of the sympathetic (fig. 184, 1).

(*b*) Appearing on the surface of the psoas is the genito-crural nerve, dividing into its two branches (fig. 184, 11).

(*c*) Emerging from under the muscle near the brim of the pelvis are the obturator nerve and lumbo-sacral cord (fig. 184, 25).

FIG. 184.—THE LUMBAR PLEXUS. (*Hirschfeld and Leveillé.*)



1. Right gangliated cord of sympathetic. 2. Abdominal aorta. 3, 3. Last dorsal nerves. 4. Psoas parvus. 5. Quadratus lumborum. 6. Psoas magnus. 7, 7. Ilio-hypogastric nerves. 8. Iliacus internus. 9, 9. Ilio-inguinal nerves. 10. Lumbo-sacral nerves. 11, 11. Genito-crural nerves. 12. Gluteal nerve. 13. Iliac branch of ilio-hypogastric nerve. 14. Sacral plexus. 15, 15, 15. External cutaneous nerves. 17. Transversalis abdominis. 19. Obliquus internus. 21. Obliquus externus. 23, 23. Anterior crural nerves. 25, 25. Obturator nerves. 27, 27. Crural branch of genito-crural nerve. 29. Genital branch of genito-crural nerve. 31. External iliac artery. 33 External abdominal ring.

(*d*) Piercing the outer border of the muscle the following nerves successively appear: last dorsal, ilio-hypogastric, ilio-inguinal, external cutaneous and anterior crural.

Lumbar Plexus.—The following nerves enter into the formation of the lumbar plexus (fig. 148):

(*a*) A twig from the twelfth dorsal nerve.
(*b*) The first, second, and third lumbar nerves.
(*c*) A part of the fourth lumbar nerve.

Only the anterior divisions of these nerves enter into the formation of the plexus.

The abdominal aorta, vena cava, common and external iliac arteries are to be removed. To expose the plexus the origin of the psoas muscle is to be detached from below upwards by the use of the handle of the scalpel. The plexus is imbedded in the origin of the muscle.

Nerves derived from the Lumbar Plexus (fig. 184).—

(1) The ilio-hypogastric (L. 1, sometimes also from D. 12).

(2) The ilio-inguinal (L. 1, sometimes also from L. 2).

(3) Genito-crural (L. 2, fibres from L. 1 or L. 3).

(4) External cutaneous (L. 2, fibres from L. 1 or L. 3).

(5) Anterior crural (L. 2, 3, 4).

(6) Obturator (L. 2, 3, 4). The fibres of the lumbar nerves composing the obturator are ventral in origin (anterior) to those of the anterior crural.

(7) Motor twigs to the quadratus lumborum (D. 12–L. 2) and psoas (L. 2–L. 3).

The *ilio-hypogastric and ilio-inguinal* (fig. 184, 7, 9) are frequently combined together, forming a first lumbar nerve, with a ramification similar to the nerve above it, the twelfth dorsal. The nerves cross the quadratus lumborum behind the kidney. The ilio-inguinal, above the crest of the ilium, enters the abdominal wall. Its distribution to the skin of the scrotum and labium majus and its course through the inguinal canal have been already followed (fig. 132, p. 24). The ilio-hypogastric takes the same course as the twelfth dorsal. Its distribution to the skin and muscles of the lower part of the abdominal wall has been examined (fig. 132).

The *genito-crural nerve* (fig. 184, 11) emerges on the anterior and inner surface of the psoas, and passes downwards on the outer side of the iliac vessels. Its distribution has been followed to the cremaster (genital branch) and to the skin of the thigh below the middle third of Poupart's ligament (crural branch).

The *external cutaneous* nerve (fig. 184, 15) emerges from the outer side of the psoas muscle, crosses the iliacus, and enters the thigh beneath the outer attachment of Poupart's ligament. It is a cutaneous nerve.

The **Anterior Crural Nerve** (fig. 184, 23) supplies the skin on the thigh (antero-internal aspect), leg, and foot (inner aspect), and the extensor muscles of the knee and flexors of the hip.

It is formed in the psoas muscle; it emerges at the outer border of the muscle; it then lies on the iliac fascia and iliacus. It emerges beneath Poupart's ligament, $\frac{1}{4}$ inch to the outer side of the femoral artery. Twigs from it supply the iliacus muscle.

The **Obturator Nerve** (fig. 184, 25) is the motor nerve of the adductor muscles of the thigh and also supplies articular twigs to the hip and knee joints, with slight branches to the skin of the inner aspect of the thigh. In its course there are three stages: (1) lumbar; (2) pelvic; (3) crural. The crural stage has been already examined (p. 192, Part I).

The *lumbar stage* lies in the origin of the psoas and between the inner border of the psoas and base of the sacrum. Here it lies with the ilio-lumbar artery, ascending lumbar vein, and lumbo-sacral cord.

The *pelvic stage* (fig. 192, 13, p. 162) extends on the lateral wall of the pelvis from the ala of the sacrum to the obturator canal, where the nerve enters its crural stage. On the lateral wall of the pelvis it lies beneath the peritoneum and above the obturator vessels. This part of its course will be again examined. In both the lumbar and pelvic stages, the nerve may be subjected to pressure from tumours or abscesses; the pain is referred to the termination of the nerve in the thigh.

Lumbo-sacral Cord (fig. 192, 12, p. 162).—The lumbo-sacral cord makes up a large part of the sacral plexus. It is formed by the fifth lumbar nerve, and half, sometimes more, sometimes less, of the fourth lumbar nerve—the *nervus furcalis*, which thus enters into the formation of both lumbar and sacral plexuses. The cord lies on the ala of the sacrum with the obturator nerve, and is overlapped by the inner border of the psoas muscle. The internal iliac artery and vein lie in front and superficial to it. The gluteal artery passes backwards between the cord and first sacral nerve (fig. 198, p. 171).

Ilio-lumbar Artery (fig. 203, p. 179).—This artery arises from the internal iliac or its posterior division, between the ala of the sacrum and the inner border of the psoas. It divides at once into *iliac* and *lumbar* branches.

The *iliac branch* passes outwards beneath the psoas and ramifies in the iliac fossa, supplying the iliac muscle and bone, and anastomosing with twigs of the deep circumflex iliac and gluteal arteries.

The *lumbar branch* ascends beneath the origin of the psoas between the obturator nerve and lumbo-sacral cord. It supplies the psoas, and sends spinal branches through the intervertebral foramina to the spinal canal and cord. It anastomoses with the lumbar arteries and deep circumflex iliac.

Ascending Lumbar Vein (fig. 232, 22, p. 231).—The vein accompanying the lumbar branch of the ilio-lumbar—the ascending lumbar—ends below in the common iliac vein. It lies behind the psoas, joins above with a radicle of the vena azygos, and communicates with the lumbar veins.

Radicles of the Azygos Veins.—The *vena azygos major* (fig. 232, p. 231) commences in the right side of the abdomen by two radicles: one from the ascending lumbar vein, which may enter the thorax beneath the internal arcuate ligament, and one from the right renal vein, which enters on the right side of the aortic opening. The *vena azygos minor* commences by similar radicles on the left side. When the return of the blood through the inferior vena cava is obstructed, these communications open up; so do those in the anterior abdominal wall.

Ligaments in the Lumbar Region.—The psoas, iliacus, quadratus lumborum, and lumbar plexus are to be cleaned away, so as to expose the intervertebral foramina and the ligaments between the vertebræ, sacrum, and ilium. The arcuate ligaments are to be defined. The fourth and fifth lumbar nerves are detached as they emerge, and the lumbo-sacral cord thrown downwards.

The *internal arcuate ligament* (fig. 183) is a fibrous thickening over the upper fibres of the psoas muscle. Internally it is continuous with the crus; externally it is attached to the tip of the first lumbar transverse process. It gives origin to diaphragmatic fibres, and is continuous with the psoas fascia.

The *external arcuate ligament* spans the insertion of the quadratus to the twelfth rib. Internally it is continuous with the internal arcuate; externally it is attached to the twelfth rib. It is continuous with the anterior sheath of the quadratus, and gives origin to arcuate fibres of the diaphragm.

Inter-transverse ligaments and muscles will be seen between the transverse processes of the lumbar region.

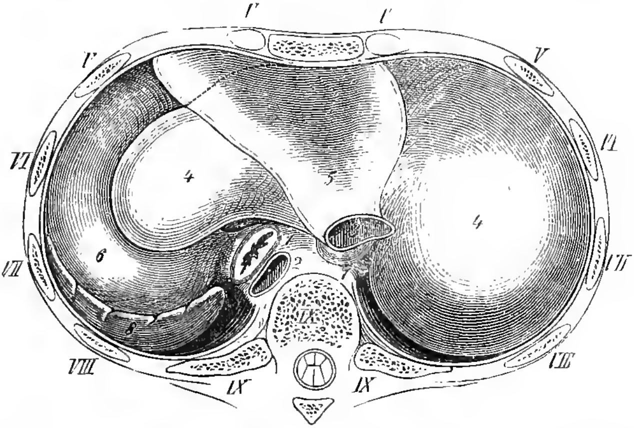
The *ilio-lumbar* ligament binds the tip of the fifth lumbar transverse process to the posterior part of the iliac crest (fig. 194, 2, p. 165).

The *lumbo-sacral* ligament binds the same processes to the base of the sacrum. Both these ligaments strengthen the bond between trunk and pelvis (fig. 194, 3, p. 165).

The *superior and anterior* sacro-iliac fibres form part of the capsule of the sacro-iliac articulation (fig. 194, 4, p. 165). They are composed of short transverse fibres passing between the alæ of the sacrum and ilium. When cut away, the ilio-sacral joint is laid open.

The *anterior common ligament of the spine* receives the fibres of the crura of the diaphragm. It is attached to the borders of the vertebræ and intervertebral discs; it widens as it descends, and ends below in the fibrous tissue in front of the sacrum. Notice the wedge shape of the last lumbar vertebra and disc; they give rise to the greater part of the lumbar curvature.

Fig. 185.—The abdominal viscera below the diaphragm. (*Braune.*)



1. Œsophagus. 2. Aorta 3. Inferior vena cava. 4, 4. Liver. 5. Pericardial portion of diaphragm. 6. Cardiac end of stomach. 7. Splenic flexure of colon. 8. Spleen. The roman numerals indicate the ribs and vertebra.

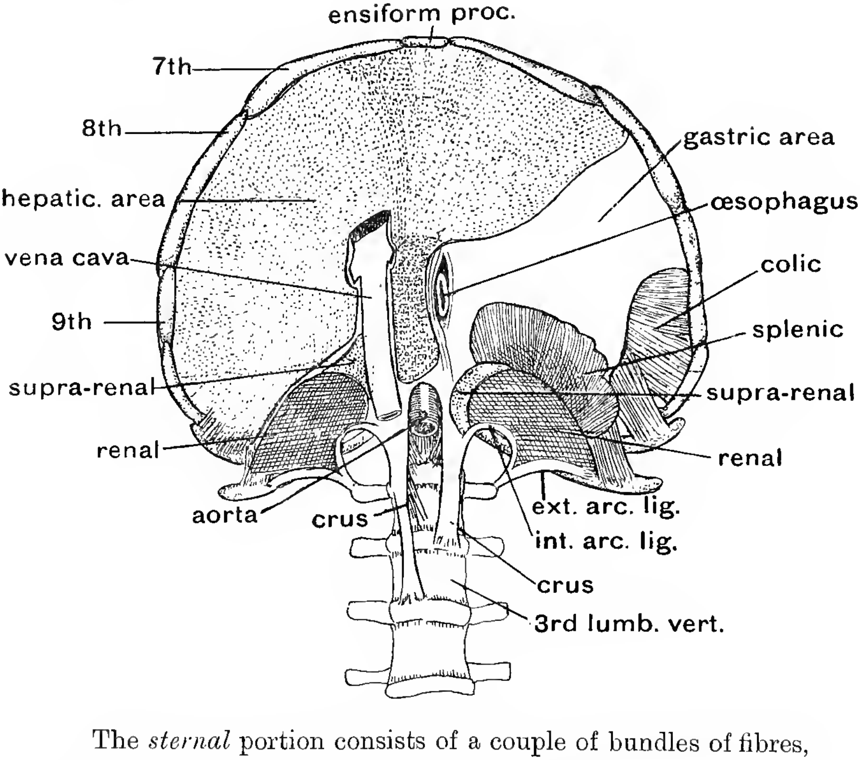
The **Diaphragm** is a muscle of respiration, and its dissection therefore belongs to the dissectors of the thorax. Its relationships to the abdominal viscera are most important (fig. 185A); the structures passing between the thorax and abdomen perforate it; it forms the dome-shaped roof and a great part of the posterior wall of the abdominal cavity. It is therefore right that the dissectors of the abdomen should study it. To expose it more freely, divide the spine below the attachment of the crura at the third lumbar disc.

Its relationship to the peritoneum is shown in fig. 153, p. 67, to the abdominal viscera in figs. 185 and 185A, and to the pleura and thoracic viscera in fig. 238, p. 243.

The diaphragm is an arched musculo-tendinous partition between the thorax and abdomen (figs. 186 and 187).

ORIGIN.—It arises from (1) the sternum; (2) costal cartilages; (3) arcuate ligaments; and (4) vertebræ. It is inserted into a flattened trefoil central tendon.

FIG. 185A.—THE RELATIONSHIPS OF THE ABDOMINAL SURFACE OF THE DIAPHRAGM.



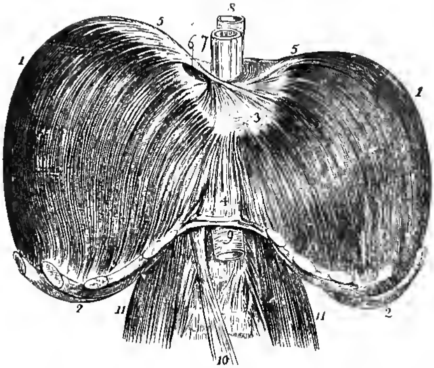
The *sternal* portion consists of a couple of bundles of fibres, arising from the back of the ensiform cartilage and inserted into the anterior margin of the central tendon.

The *costal* portion arises by fleshy bundles from the inner surfaces of the six lower costal cartilages. These interdigitate with the transversalis abdominis, and are inserted into the anterior and lateral margins of the central tendon.

The *vertebral* portion (fig. 187) arises by two strong tendons, the *pillars* or *crura*, of which the right is the longer. The right crus arises from the bodies of the three upper lumbar vertebræ and discs, the left extending only as far as the second vertebra. The muscular fibres from the crura pass upwards and forwards to the posterior border of the central tendon, the innermost fibres decussating in front of the aorta, which lies between the crura. These decussating fibres also embrace the œsophagus before they reach the central tendon (fig. 187).

In the interval between the crura and the costal attachments, the diaphragm arises from two tendinous bands which arch over the psoas and quadratus lumborum muscles (fig. 185A). The *ligamentum arcuatum internum* extends from the body to the transverse process of the first lumbar vertebra, and is a thickening of the fascia of the psoas muscle. The *ligamentum arcuatum externum* stretches between the transverse process of the first lumbar vertebra and the last rib, being the thickened upper portion of the fascia over the quadratus lumborum.

Fig. 186.—The thoracic surface of the diaphragm. (*Wilson.*)



1, 1. The lateral segments of the thoracic portion ; arising from 2, 2, the cartilages of the ribs ; and inserted into 3, the central tendon. The right segment is seen to be higher than the left. 4. The fasciculus which arises from the ensiform cartilage. 5, 5. Lateral leaflets of the central tendon. 6. Opening for the inferior vena cava. 7. The œsophagus. 8. The thoracic aorta. 9. The abdominal aorta. 10. The tendon of the right crus of the diaphragm : that of the left is seen immediately above on the lumbar vertebræ. 11, 11. The psoas muscles.

The *central tendon or aponeurosis*, on the edge of which the muscular fibres end, occupies the highest level of the diaphragm and forms a platform on which the heart rests. The heart occupies the middle part; a lateral cornu or leaflet diverges backwards and outwards in each lateral dome (fig. 187).

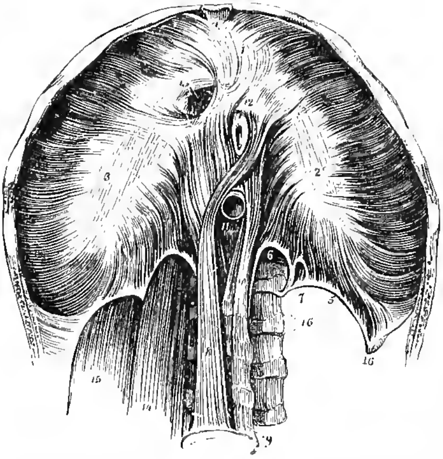
Nerve Supply.—From the phrenic nerve. Twigs from the intercostals also enter it. The phrenic is its motor nerve ; its branches perforate and are distributed on the under surface of the diaphragm.

Blood Supply.—Inferior phrenic (from the abdominal aorta); superior phrenic (internal mammary); musculo-phrenic (internal mammary); twigs from the lower six intercostal arteries.

Action.—Part of the central tendon of the diaphragm is fixed and rendered nearly immovable by (1) the attachment of the pericardium, (2) mediastinal pleuræ, (3) venæ cavæ (fig. 237, p. 240). These structures are bound below to the diaphragm, and above to the sternum and the deep cervical fascia of the neck.

The lateral parts form the dome-like floor of the pleural cavities (fig. 186), which they enlarge by a combined downward and forward movement, thus causing the abdominal contents to descend in a similar direction. The costal and sternal parts, through their common points of origin, are continuous with the muscles forming the abdominal wall. The diaphragm is a muscle of inspiration; the abdominal wall, of expiration.

Fig. 187.—The abdominal aspect of the diaphragm. (*Wilson.*)



1. The central leaflet of the tendinous centre. 2. The left or smallest leaflet. 3. The right leaflet. 4. Fasciculus from the ensiform cartilage. 5. Ligamentum arcuatum externum of the left side. 6. Ligamentum arcuatum internum. 7. A small arched opening for the least splanchnic nerve (occasional). 8. Right crus. 9. Fourth lumbar vertebra. 10. Left crus. 11. Aortic opening. 12. Œsophageal opening. 13. Opening for the inferior vena cava. 14. Psoas magnus passing beneath the ligamentum arcuatum internum. 15. Quadratus lumborum passing beneath the ligamentum arcuatum externum. 16. Tip of last rib.

Openings in the Diaphragm (fig. 187). Certain openings are found in the diaphragm for the transmission of the aorta, œsophagus, inferior vena cava, and some small vessels and nerves.

(1) The *aortic opening* is mesial in position, and lies between the crura, opposite the twelfth dorsal vertebra. It transmits the aorta, vena azygos major, and thoracic duct.

(2) The *œsophageal opening* is surrounded by muscle and placed slightly in front and to the left of the aortic opening, at the level of the tenth dorsal vertebra. It trans-

mits the œsophagus, pneumogastric nerves, and œsophageal arteries.

(3) The *caval opening* (foramen quadratum) is a little to the right and in front of the aortic opening, and lies in the central tendon, opposite the interval between its middle and right leaflets (fig. 187, 13). It is the highest of the three openings, and lies opposite the ninth dorsal vertebra and sixth costal cartilage at the right side of the sternum.

(4) Between the sternal and costal portions of the diaphragm is a narrow hiatus through which the superior epigastric artery reaches the abdomen on each side (fig. 235, p. 237). In this opening the pleura and peritoneum are separated only by a thin layer of areolar tissue.

(5) The splanchnic nerves pierce the crura, and the vena azygos minor passes through the left crus. The gangliated cord of the sympathetic issues from the thorax beneath the internal arcuate ligament. The branches of the phrenic nerves pierce the diaphragm to be distributed on its under surface beneath the peritoneum. The pleura and pericardium, with the lungs and heart, lie on the thoracic surface of the diaphragm (fig. 238, p. 243). In relation to its under surface are the peritoneum, liver, stomach, spleen, pancreas, kidneys, suprarenal bodies and inferior phrenic vessels (figs. 185 and 185A).

DISSECTION VIII

THE UROGENITAL REGION OF THE PERINEUM

The scrotum, testes, and free part of the penis have already been examined in the male; the external genital organs in the female (see Dissection V).

The RECTAL PART (rectal triangle) of the perineum—that part lying behind a line drawn from the anterior border of one ischial tuberosity to the other—and the ischio-rectal fossæ have been dissected (see Dissection II).

There now remain for examination the structures which lie in front, and fill up the interval of the pubic arch. They are situated in the UROGENITAL PART (urogenital triangle) of the perineum.

In the male the structures to be examined are (see Plates XXXIX, XLI, and fig. 189):

(1) The root of the penis; its attachment; the vessels and nerves to the penis.
(2) The urethra (membranous and bulbous stages).
(3) The muscles of the urogenital perineum:
  (*a*) Bulbo-cavernosus (ejaculator urinæ).
  (*b*) Ischio-cavernosus (erector penis).
  (*c*) Transversus perinei.
  (*d*) Compressor (constrictor) urethræ.
(4) Glands of Cowper.
(5) The triangular ligament.

Deep to all these structures the prostate is situated, within the cavity of the pelvis and behind the symphysis pubis (fig. 189, 8). The aim of the dissection of this region is to expose the perineal aspect of the prostate (Plate XLI, p. 158) and obtain a correct conception of the arrangement of structures between it and the surface of the perineum. As a surgeon, the student has to know accurately how to expose in the perineum every one of the structures just named.

In the female the following structures are to be exposed (fig. 188):

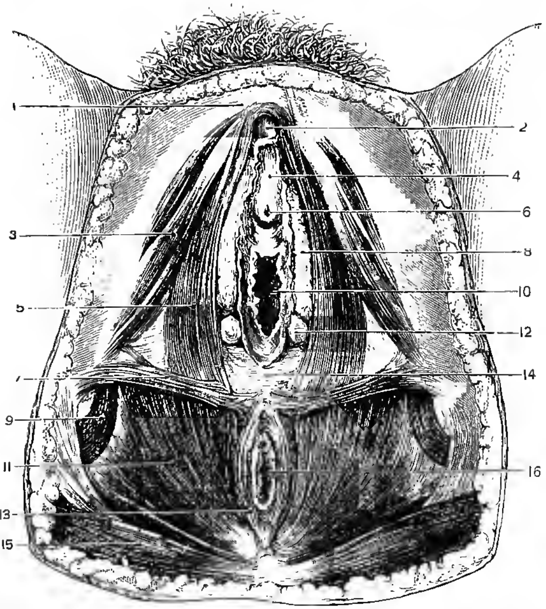
(1) Perineal attachments of the clitoris and bulbi vestibuli; the blood vessels of the clitoris and bulbs.
(2) The urethra.
(3) Opening of the vagina.
(4) Muscles of the urogenital perineum:
  (*a*) Ischio-cavernosus (erector clitoridis).
  (*b*) Bulbo-cavernosus (sphincter vaginæ).
  (*c*) Transversus perinei.
  (*d*) Constrictor urethræ.
(5) The glands of Bartholin.
(6) The triangular ligament.

THE UROGENITAL REGION OF THE FEMALE

The width of the pubic arch and urogenital space is much greater in the female than in the male, to allow the passage of the child at birth.

The Central Tendinous Point of the Perineum.—When the skin is removed from the perineal body (the wedge-shaped mass of tissue between the anal canal and vagina, see fig. 195, 15, 16, 17, p. 167), a fibrous point or septum will be found between the anus and vulval cleft, at which four muscles are attached and through which they are partly continuous (fig. 188, 14). Here the anterior end of the external anal sphincter, and the posterior end of the vaginal sphincter, are attached. The transversi perinei, extremely variable muscular slips, end on each side of the central tendinous point. These four muscles maintain and compress the perineum of the female.

Fig. 188.—Dissection of the female perineum. (*Savage.*)



1. Pubes. 2. Clitoris. 3. Erector clitoridis. 4. Vestibule. 5. Bulbo-cavernosus muscle. 6. Urethra. 7. Superficial transverse muscle. 8. Bulb of vestibule 9. Obturator internus muscle. 10. Vagina. 11. Levator ani muscle. 12. Gland of Bartholin. 13. Sphincter ani externus. 14 The perineal body. 15. Gluteus maximus. 16. Anus.

Sphincter Vaginæ (Bulbo-cavernosus) (fig. 188, 5).—Origin. From the central tendinous point or area of the perineum.

Insertion.—The fibres form a loose wide band of scattered fibres on each side of the vulval cleft and opening of the vagina. They end on (1) the crura of the clitoris; (2) fibrous tissue of the vestibule; (3) over and around the opening of the urethra.

Nerve Supply.—Deep perineal nerve.

The skin, superficial fascia, nerves and vessels of the labia majora and minora have to be reflected to expose the muscle. Beneath it lie the *bulbi vestibuli*, erectile bodies corresponding to the divided corpus spongiosum (fig. 188, 8). In the male, the corresponding muscle covers the bulb of the corpus spongiosum. The muscle becomes ruptured and partly destroyed in parturition.

Transversus Perinei (fig. 188, 7).—The transversus perinei passes on each side from the inner aspect of the ischial ramus, at the anterior end of the ischial tuberosity, to the central tendinous point. There may be deep and superficial bands. It may be well marked or absent. It is supplied from the superficial perineal nerves which cross superficially as they pass forwards (fig. 192, 42, 44, p. 162).

Erector Clitoridis (Ischio-cavernosus) arises over the attachment of the crus of the clitoris to the inner aspect of the pubic arch (fig. 188, 3). It ends on the crus, forming a fibro-muscular sheet on it. The deep perineal nerve supplies it ; its action is slight.

Perineal Nerves.—The pudic nerve, which has already been dissected in the outer wall of the ischio-rectal fossa (Plate XLI), should be traced forwards and the following branches found :

(1) Two *superficial perineal nerves*, external or posterior and internal or anterior (fig. 192, 42, 44). They arise in the anterior part of the ischio-rectal fossa, and end in the skin and mucous membrane of the labia and vulval cleft.

(2) The *deep perineal nerve* (fig. 192, 46) supplies the urogenital muscles and ends in the vestibule. It also arises from the perineal division of the internal pudic nerve in the ischio-rectal fossa.

(3) The *dorsal nerve of the clitoris* (fig. 192, 29) passes forwards between the layers of the triangular ligament, and ends in the bulb, crus clitoridis, mucous membrane of the glans, clitoris and vestibule.

(4) The *long pudendal branch* of the small sciatic. It makes a semicircle an inch distant from the ischial tuberosity (fig. 192, 31). It ends in the labia majora.

Perineal Arteries.—The internal pudic artery gives off the following branches, which should be traced (see corresponding arteries in the male, Plates XXXIX, p. 14, and XLI, p. 158).

(1) The *superficial transverse* perineal arises in the anterior

part of the ischio-rectal fossa; it ends in the perineal body (Plate XXXIX, p. 14).

(2) The *superficial perineal* arises with the last and supplies the labia and walls of the vulval cleft.

(3) The *dorsal artery* of the clitoris, the *artery to the bulb*, and the branch to the *corpus cavernosum* are small terminal twigs which arise from the pudic artery between the layers of the triangular ligament.

The deep and superficial *external pudic* arise from the femoral artery. The dorsal vein of the clitoris ends in the vesical plexus (fig. 205, 18, p. 183).

Clitoris.—The corpora cavernosa of the clitoris are small fibrous tubes containing a small amount of erectile tissue. They diverge as they pass backwards, and end on the *inner* or crural impressions of the pubic arch (fig. 190). The point of insertion is marked by an evaginated tuberosity, the crural tuberosity. In the male both the impression and tuberosity are much larger, and afford a safe guide to the sexual character of a pelvis (fig. 190).

The **Gland of Bartholin** is situated in the lateral wall of the vulval cleft, at the opening of the vagina (fig. 188, 12). It corresponds to the gland of Cowper in the male. Its duct, half an inch long, opens in the vulval cleft at the antero-lateral margin of the vagina. A pit frequently marks the point of opening. Both the gland and duct are hard to find in women who have borne children.

The **Bulbi Vestibuli** (fig. 188, 8) are two oval masses of veins and erectile tissue situate one on each side of the vestibule under the labia minora and sphincter vaginæ. They are placed on the surface of the triangular ligament, and represent the divided bulb of the corpus spongiosum of the male.

Triangular Ligament.—When the sphincter vaginæ, transversus perinei, the perineal vessels and nerves, the bulbs, the crura clitoridis and muscles are cleared away, the triangular ligament is seen as a fibrous layer forming an ill-defined membrane round the urethra and mouth of the vagina and uniting them loosely to the pubic arch. Two layers are not distinguishable. The ligament lies on the perineal surface of the levator ani and belongs to the sheath of that muscle. It strengthens the outlet of the pelvis.

Female Urethra (fig. 195, 11, p. 167).—A catheter has already been passed into the bladder and the meatal opening on the vestibule examined (fig. 188, 6, p. 151). It is $1\frac{1}{4}$ inches long, and can be forcibly dilated in life until it is big enough to take the fore-finger. The urethra is imbedded in the roof of the vagina. Crypts and glands occur in its mucous lining. A sphincter muscle (the constrictor urethræ) surrounds it. In front the sphincter fibres form loops over the urethra and bind it to the roof of the vagina (fig. 188).

THE UROGENITAL REGION OF THE MALE

Before commencing the actual dissection of this region, it is necessary to study a vertical section such as is shown in fig. 189, in order to note the relative position of the numerous structures in it.

In a vertical section of the urogenital region of a male pelvis the following structures are seen (fig. 189):

(1) The oval section of the symphysis pubis and subpubic ligament (6).

(2) The *prostate* surrounding the first (prostatic) stage of the urethra (8). The ejaculatory ducts open into it (25). The *prostatic stage* of the urethra is nearly vertical in the standing position.

(3) The two layers of the *triangular ligament*, and the *membranous stage* of the urethra between them (15). The *constrictor urethræ* surrounds this stage (13). The apex of the prostate lies on the posterior layer; the thick fibrous capsule of the prostate unites and fuses with the deep layer of the ligament.

(4) The *bulb of the corpus spongiosum* (11) surrounding the bulbous stage of the urethra, which, with the membranous and prostatic stages, forms nearly half a circle below and behind the symphysis pubis. The deep surface of the bulb adheres to the anterior layer of the triangular ligament; its perineal surface is covered by the bulbo-cavernosus (ejaculator urinæ).

(5) *Colles's fascia* (12), forming a covering for the urogenital region. It lies beneath the skin and subcutaneous tissue. It is continuous behind with the base of the triangular ligament and central point of the perineum (15).

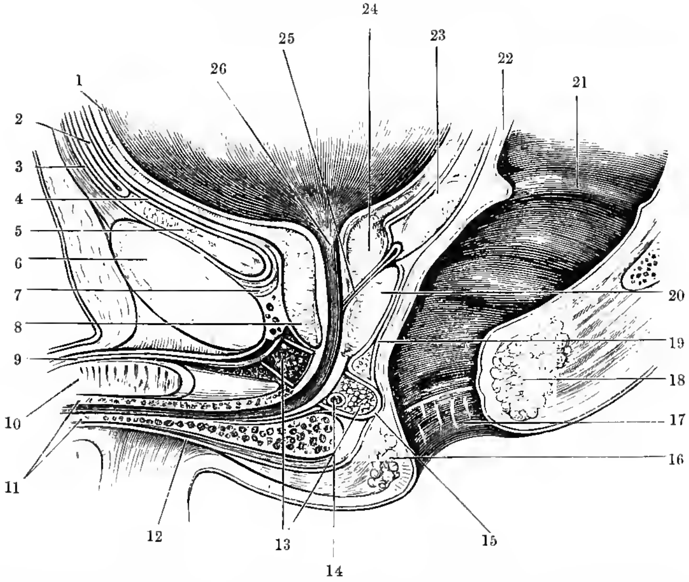
(6) The *perineal body*, a wedge-shaped mass of tissue in which the central tendinous point is situated. As seen in

section it separates the anal canal behind (17) from the bulb and triangular ligament and apex of the prostate in front.

There are also some points which should be examined on THE SUBPUBIC ARCH (fig. 190). The width of the subpubic arch of the male should be noted; it is less than in the female.

(1) The pubic arch shows two internal borders, a prominent *anterior* and a less plainly marked *posterior*. To the posterior border are attached the layers of the triangular ligament, the obturator and anal fasciæ (see fig. 199, p. 173); to the anterior border, the fascia lata and fascia of Colles.

FIG. 189.—SEMI-DIAGRAMMATIC SECTION OF THE MALE PERINEUM. (*From Morris's 'Anatomy.'*)



1. Mucous membrane of bladder. 2. Peritoneum. 3. Fascia transversalis. 4. Recto-vesical fascia. 5. Fat in space of Retzius. 6. Symphysis. 7. Pubo-prostatic ligament. 8. Anterior wall of prostate with capsule. 9. Dorsal vein of penis. 10. Septum pectiniforme. 11. Corpus spongiosum urethræ. 12. Fascia of Colles. 13. Deep transversus perinei and constrictor urethræ between superficial and deep layers of triangular ligament. 14. Cowper's gland. 15. Junction of deep and superficial triangular layers of ligament with fascia of Colles. 16. Sphincter ani. 17. Anal canal. 18. Sphincter ani. 19. Rectal portion of recto-vesical fascia. 20. Posterior wall of prostate with capsule. 21. Cavity of rectum showing one of Houston's valves. 22. Anterior wall of rectum. 23. Vasa deferentia and vesiculæ seminales. 24. 'Middle lobe' of prostate above the prostatic fissure. 25. Sinus pocularis in prostatic fissure. 26. Internal urinary meatus.

(2) The surface between these two borders gives attachment to the crura of the penis (corpora cavernosa) (fig. 190);

the points of attachment are marked by a tuberosity (crural tuberosity) and a wide everted impression (the crural impression).

DISSECTION.—A median incision is made along the *perineal raphe* from the section of the crus penis in front to the anus behind. The skin is raised and removed.

The *sphincter ani*, or external sphincter, was already seen in the dissection of the rectal part of the perineum (Plate XXXIX, p. 14). It consists of a number of elliptical fibres which *arise* posteriorly from the tip of the coccyx and ano-coccygeal ligament, and having surrounded the anus are *inserted* into the central point of the perineum. Some of the deeper fibres blend with fibres of the levator ani.

The *central point of the perineum* lies about an inch in front of the anus, and marks the point of confluence of certain muscles, viz. the sphincter ani behind, the accelerator urinæ or ischio-cavernosus muscle in front, the transverse perineal muscles laterally, and the levatores ani on its deep or perineal surface (Plate XLI, p. 158).

Superficial Fascia.—The superficial fascia of the anterior part of the perineum is arranged in two layers, a superficial fatty layer and a deep membranous layer.

The *superficial fatty layer* is continuous with the superficial fascia of the adjoining regions; behind, with the fat of the ischio-rectal fossa, laterally with the superficial fascia of the thigh, and anteriorly with the subcutaneous tissue of the scrotum.

The *deep layer*, or **fascia of Colles,** is membranous in structure and is attached laterally and behind, but in front is continued uninterruptedly into the dartos tissue of the scrotum and Scarpa's fascia of the groin (fig. 130, p. 22). *Posteriorly* it winds over the surface of the transversus perinei muscles to be attached to the posterior border of the triangular ligament (fig. 189, 15). *Laterally* it is attached to the rami of the ischium and pubis, external to the erector penis muscle. Its deep surface covers over the urogenital triangle containing the bulb and the superficial perineal muscles, and forms a 'superficial perineal pouch' (Plate XLI). The deep boundary of the pouch is formed by the triangular ligament.

This pouch is partially subdivided by the median attachment of the deep surface of the fascia of Colles to the subjacent bulb of the urethra. This attachment is deficient in front of the bulb, so that the two lateral parts of the pouch communicate. The attachments of the fascia of Colles explain why urine, extravasated from the urethra in front of the triangular ligament, passes forwards under the dartos tissue of the scrotum and subcutaneous tissue of the penis to reach the front of the pubis and anterior abdominal wall, where it accumulates between the superficial fascia and the abdominal muscles. The fascia of Scarpa prevents it passing to the thigh (fig. 130, p. 22). The fluid is prevented from reaching the ischio-rectal fossa, or inner side of the thigh, by the attachment of the fascia of Colles to the posterior border of the triangular ligament and the ischio-pubic rami (Plate XLI).

The *superficial perineal pouch* (fig. 189) contains (1) the bulb, covered by (2) the bulbo-cavernosus; externally on each side is (3) the crus penis, covered by (4) the ischio-cavernosus. (5) The transversus perinei muscle lies within its posterior fornix.

The ischio-cavernosus, bulbo-cavernosus, and transversus perinei bound between them the *superficial perineal triangle* (Plate XLI), the floor of which is formed by the triangular ligament. Passing forwards in the pouch are the superficial perineal vessels and nerves.

Superficial Perineal Vessels and Nerves (Plates XXXIX, p. 14, and XLI).—The *superficial perineal arteries,* one or two in number, are derived from the internal pudic artery as it lies in Alcock's canal. They pass forwards and reach the anterior part of the perineum by piercing Colles' fascia near the posterior border of the triangular ligament. They then pass usually over the transversus perinei muscle, and, having supplied branches to the superficial perineal muscles, are distributed to the integument of the perineum and scrotum.

The *superficial transverse perineal artery* is a small branch of the internal pudic, which ramifies on the superficial surface of the transversus perinei muscle (Plate XXXIX, p. 14).

The *superficial and deep external pudic arteries* were traced from the femoral artery to the scrotum and perineum in the dissection of the thigh. They anastomose with the branches of the internal pudic.

Nerves to the Skin of the Perineum and Scrotum.—These are:

(1) Inguinal branches of the ilio-inguinal to the scrotum in the inguinal region (from first lumbar, see fig. 184, 33, p. 141).

(2) Pudendal branch of the small sciatic (from third sacral) (fig. 192, 31, p. 162).

(3) Two superficial perineal nerves from the pudic (from third and fourth sacral).

The *superficial perineal nerves*, two in number, *internal* or anterior (fig. 192, 44), and *external* or posterior (fig. 192, 42), are branches of the perineal nerve, which is derived from the pudic nerve in the anterior part of the ischio-rectal fossa. Having pierced the posterior part of the fascia of Colles, they pass forwards in the superficial perineal pouch, and supply the skin over the anterior part of the perineum. Some long branches, the *long scrotal nerves*, reach forwards to the skin of the scrotum (Plate XXXIX, p. 14). The external branch communicates with the long pudendal and inferior hæmorrhoidal nerves.

The *long pudendal nerve*, a branch of the small sciatic (fig. 192, 31), appears from underneath the gluteus maximus, and passes forwards and inwards on the hamstring muscles about one inch and a half in front of the tuberosity of the ischium. It supplies the skin in the anterior part of the perineum, and communicates with the external superficial perineal nerve.

Superficial Perineal Muscles (Plates XXXIX and XLI).—The superficial perineal muscles are the bulbo-cavernosus, the ischio-cavernosus, and the transversus perinei. They are now to be carefully cleaned, but without some knowledge of the arrangement of the root of the penis their disposition will not be understood.

It should be remembered that the three parts of the penis, viz. the corpus spongiosum and corpora cavernosa, are prolonged backwards into the perineum (fig. 150c, p. 59), forming the root of the penis. The corpus spongiosum passes to the surface of the triangular ligament and becomes enlarged, forming the *bulb*, which receives the membranous portion of the urethra as it pierces the triangular ligament (fig. 189). The corpora cavernosa diverge from each other along the ischio-pubic rami and become more fibrous in character, forming the tendon-like crus penis on each side; this is attached to the conjoined rami of the ischium and pubis. The bulbo-cavernosus clothes the bulb and adjacent part of the root of the penis; the

PLATE XLI

DEEP STRUCTURES IN THE PERINEUM OF THE MALE.

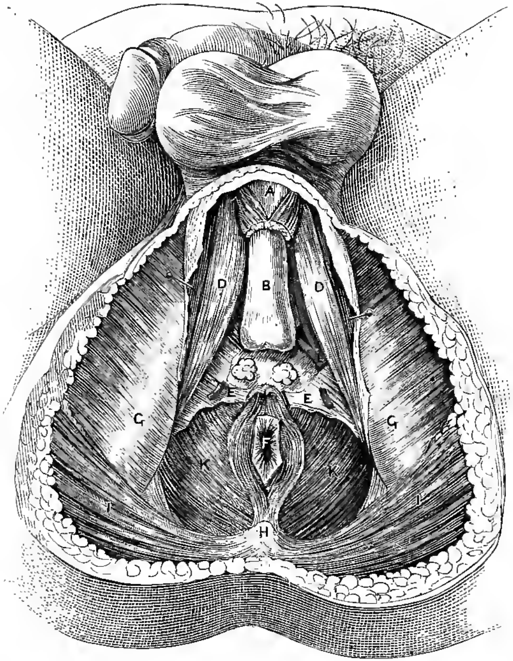


Fig. 1.—The bulbo-cavernosus removed to show the bulb of the urethra, and the triangular ligament partially removed to show Cowper's glands.

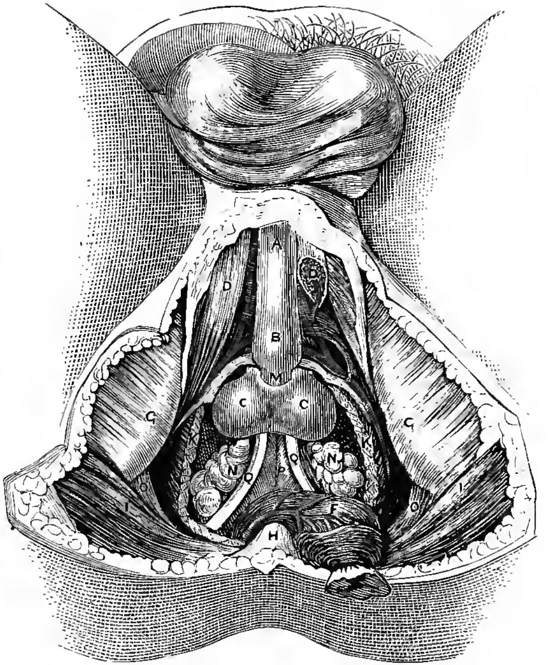


Fig. 2.—The levator ani removed, and rectum turned down to show the prostate and neck of bladder.

A. Urethra. B. Bulb. C. Prostate. D. Crus penis with ischio-cavernosus. E. Triangular ligament (cut to show Cowper's glands). F. Anus. G. Tuber ischii. H. Coccyx. I. Gluteus maximus. K. Levator ani (cut). L. Pudic artery. M. Membranous urethra. N. Vesicula seminalis. O. Great sacro-sciatic ligament. P. Base of bladder. Q. Vas deferens.

ischio-cavernosus lies over the crus penis; these form the sides of the SUPERFICIAL PERINEAL TRIANGLE whose base is formed by the transversus perinei (Plate XXXIX, fig. 2, B, D, E, p. 14).

The **ejaculator** or **accelerator urinæ,** or **bulbo-cavernosus,** arises from the central point of the perineum and from a median raphe extending forwards over the bulb. Its fibres pass over the sides of the bulb. The *posterior* fibres are inserted on the surface of the triangular ligament. The *middle* fibres, forming the greater part of the muscle, encircle the bulb of the corpus spongiosum and meet in a fibrous expansion on its dorsal surface. The *anterior* fibres form a V-shaped loop which surrounds the root of the penis (corpora cavernosa and corpus spongiosum), and are inserted into a thin aponeurosis on the dorsal surface of the penis (Plate XXXIX, p. 14).

NERVE SUPPLY.—From the deep perineal branch of the internal pudic (fig. 192, 46).

ACTION.—It expels the contents (urine, semen) from the bulbous part of the urethra.

The **erector penis,** or **ischio-cavernosus,** arises from the ischial tuberosity immediately behind the crus penis. It terminates in a fibrous aponeurosis which gradually becomes lost on the surface of the crus (Plate XXXIX, p. 14). The muscle is largely fibrous.

NERVE SUPPLY.—From the deep perineal branch of the internal pudic.

The **transversus perinei** *arises* from the inner surface of the anterior part of the ischial tuberosity and is *inserted* into the central point of the perineum (Plate XXXIX, p. 14). Its arrangement is irregular, and its borders often ill-defined. Deep and superficial strands may be recognised. It elevates and stays the perineal body. The deep perineal nerve supplies it.

The **deep perineal nerve,** which supplies the muscles of this space, arises from the perineal division of the internal pudic (fig. 192, 46, p. 162). It leaves Alcock's canal and enters the muscular triangle of the perineum beneath the transversus perinei. In the triangle it sends branches to the muscles and also to the bulb and bulbous part of the urethra.

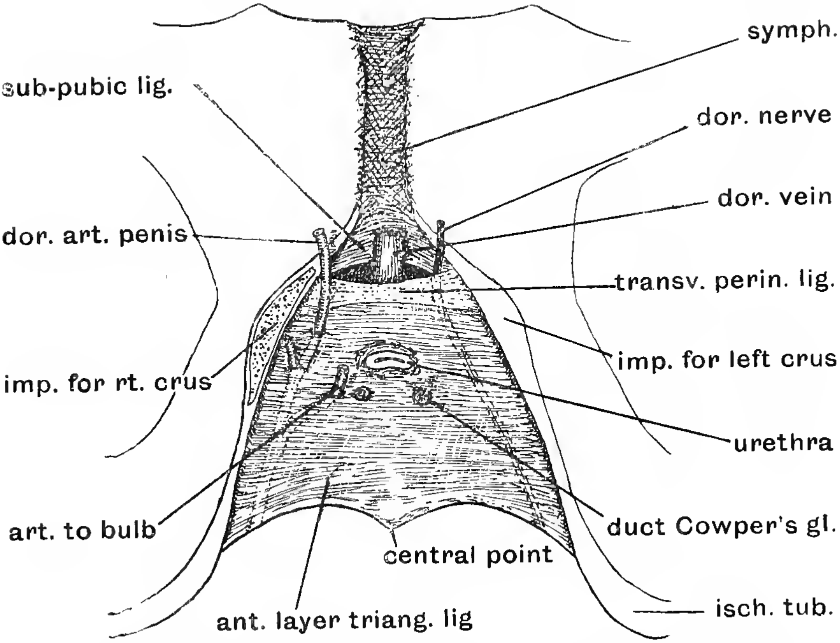
Triangular Ligament of the Perineum.—To expose this structure (Plate XXXIX, fig. 2, L, p. 14), which is already in view in the floor of the muscular triangle, the following structures, including the root of the penis, have to be cut away:

(1) The ischio-cavernosus muscle and the attachment of Colles' fascia to the anterior margin of the ramus of the pubis.

(2) The crura of the penis—the posterior ends of the corpora cavernosa—are thus exposed. They are to be elevated by a chisel from the crural impressions of the rami and examined.

(3) The bulbo-cavernosus is removed and the bulb exposed (Plate XLI, B).

Fig. 190.—The triangular ligament and impressions for the crura of the penis on the pubic arch.



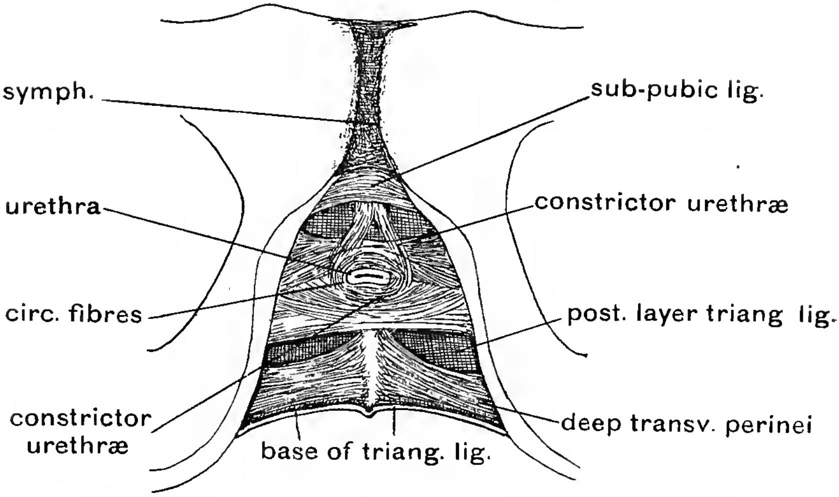
(4) The bulb (posterior dilated end of the corpus spongiosum) is to be detached, but the part attached to the triangular ligament around the urethra is to be left. Structures (1) to (4) make up the *root of the penis.*

(5) Colles' fascia, the transverse perineal muscles and perineal vessels, are to be removed.

The anterior surface of the triangular ligament is thus exposed (fig. 190). It is seen to be a slight membranous structure filling up the triangular interval of the subpubic arch. From apex to base, it is about 1¾ inches; its base is about the same in width. The base is prolonged into a point which ends in the central tendon of the perineum. The structure which the student now explores has probably not the definite layers and sharp borders he expected to see; the actual structure never fulfils the expectation raised by the description. Nevertheless, the triangular ligament is a definite and important structure.

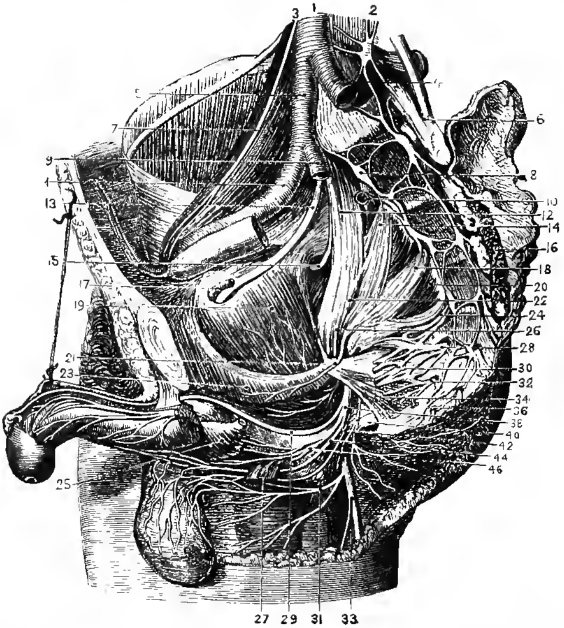
Between the apex of the triangular and subpubic ligaments is an interval through which the dorsal vein of the penis passes to the pelvis. Below the interval there is a band of transverse fibres—the transverse perineal ligament (fig. 190).

Fig. 191.—The constrictor urethræ and subpubic ligament.



Constrictor (Compressor) Urethræ.—To understand the nature of the triangular ligament a true conception of the constrictor urethræ muscle must be formed (fig. 191). This muscle is made up of three sets of fibres. The upper and lower *transverse* fibres stretch across the subpubic angle from the posterior border of one ramus to the posterior border of the other. They cross above and below the membranous part of the urethra. *Antero-posterior* fibres pass towards the symphysis. The third set is composed of deep *circular* fibres which surround the membranous urethra, and act as a sphincter, preventing the exit of urine. The muscle is supplied by the deep perineal nerve. This muscle, like every muscle in the body, has a fibrous sheath; the anterior wall of the sheath forms the anterior layer of the triangular ligament; the posterior wall forms the deep layer of the triangular ligament. It is in contact and continuous with (fig. 189) three other sheaths: (1) the capsule of the prostate gland, (2) the sheaths of the levator ani and (3) of the obturator internus muscles (see also fig. 199, p. 173). The sheaths of these four structures—constrictor urethræ, levator ani, obturator internus, and prostate—are continuous, and any separation is artificial.

Fig. 192.—The nerves of the perineum. (*Hirschfeld and Leveillé.*)



1. Abdominal aorta. 2. Gangliated cord of sympathetic (left side). 3. Genito-crural nerve. 4. Left common iliac artery. 5. Right common iliac artery. 6. Left lumbo-sacral cord. 7. Psoas muscle. 8. Gangliated cord of sympathetic (right side). 9. Internal iliac artery (cut). 10. Gluteal artery (cut). 11. Right external iliac artery. 12. Right lumbo-sacral nerve. 13. Obturator nerve. 14. First sacral nerve. 15. Gluteal nerve. 16. Pyriformis of left side (cut). 17. Obturator artery. 18. Second sacral nerve. 19. Obturator internus. 20. Pyriformis of right side. 21. Nerve to levator ani. 22. Sacral plexus. 23. Levator ani (cut). 24. Third sacral nerve. 25. Bulb of urethra covered by accelerator urinæ. 26. Nerve to obturator internus. 27. Transversus perinei. 28. Fourth sacral nerve. 29. Dorsal nerve of penis. 30. Visceral branches (cut). 31. Inferior pudendal nerve. 32. Fifth sacral nerve. 33. Small sciatic nerve. 34. Coccygeus muscle. 36. Sixth or coccygeal nerve. 38. Internal pudic nerve. 40. Inferior hæmorrhoidal nerve. 42. Posterior superficial perineal nerve. 44. Anterior superficial perineal nerve. 46. Deep perineal nerves to bulb and muscles.

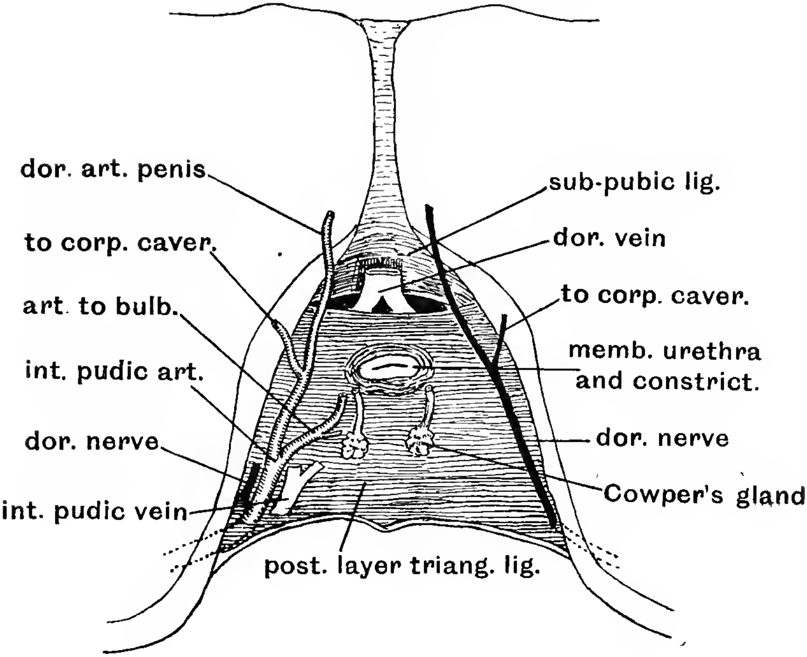
The anterior layer is now removed, and the constrictor urethræ examined. The following structures lie between the layers of the triangular ligament and perforate either one or both layers (fig. 193) :

(1) The constrictor urethræ muscle, between the layers.

(2) The membranous urethra ; it perforates both layers (fig. 189).

(3) The dorsal vein of the penis (fig. 189) pierces above both layers below the symphysis and subpubic ligament. It ends in the prostatic plexus.

FIG. 193.—DIAGRAM OF THE STRUCTURES BETWEEN THE TWO LAYERS OF THE TRIANGULAR LIGAMENT.



(4) The **glands of Cowper** (figs. 189, 193) are two in number, one on each side. Although of the size of a pea, they are hard to find. They lie amongst the posterior (lower) transverse fibres of the constrictor urethræ, on each side of the middle line deep to the bulb and anterior layer of the triangular ligament. The artery to the bulb passes inwards in front of (above) them. The ducts perforate the anterior layer of the ligament behind the urethra and open in the commencement of the bulbous part (fig. 209, p. 190).

(5) The terminal stage of the internal pudic artery (Plate XLI) pierces the base, and passes forwards between the layers of the ligament. It perforates the anterior layer to form the dorsal artery of the penis. In its course forwards it gives off a large branch to the corpus spongiosum. It is named the artery to the bulb, and is liable to injury in deep operations on the perineum. Another branch ends in the corpus cavernosum (Plate XLI).

(6) The terminal part of the pudic nerve (fig. 193). It follows the same course as the artery. It gives branches to the bulb, corpus cavernosum, and ends as the dorsal nerve of the penis.

(7) Beneath the deep layer of the triangular ligament lies the prostate (see Plate XLI, fig. 2).

DISSECTION IX

THE PELVIS AND ITS VISCERA

The following structures, which were followed in the dissection of the abdomen down to the pelvis, should be again recognised: (1) The ureter, crossing the brim at the termination of the common iliac artery; (2) the sigmoid colon to its junction with the rectum; (3) the internal iliac vessels and middle sacral; (4) the hypogastric plexus and sympathetic gangliated cord; (5) the obturator nerve and lumbo-sacral cord; (6) the ovarian vessels and round ligament of the uterus in the female; (7) the vas deferens in the male.

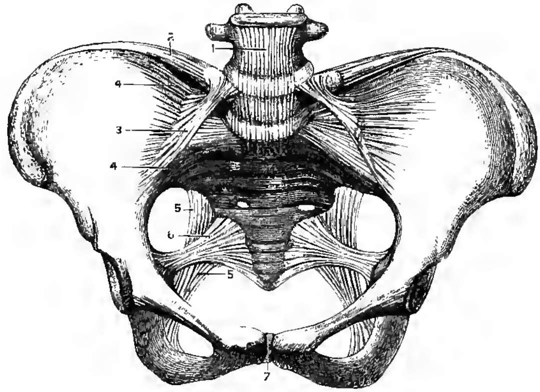
The terminations of these structures in the pelvis and the pelvic viscera are now to be examined. The arrangement and structures of both male and female will be described and the student must read and examine each, for the bodies in the room provide material of both sexes, whatever be the one he has before him for examination.

The genital organs of both sexes should have his special attention, for they, unfortunately, will require much of his attention in after-life. In the male, especially, he should note what can be felt and examined per rectum (fig. 208A), and in the female the parts accessible from the vagina (figs. 195 and 197). This he can do in the course of dissection. He must remember that coils of the small intestine occupy the vacant space of the pelvic cavity. He must study the effects produced by distension of the bladder, rectum, and uterus ; where and how they will present themselves for palpation under such circumstances. Further he should keep in mind that the pelvis of the female has to allow the passage of the child at birth.

Boundaries of the Pelvis.—These must be studied on a dried pelvis with ligaments attached, along with the part (fig. 194). The muscles of the thigh and abdominal walls must be carefully cleaned away at their attachments to the pelvis, if this has not been done already.

The *inlet* or *brim* is formed by the base and anterior alar borders of the sacrum, ilio-pectineal line and pubic crest (fig. 194). The psoas muscles, common and external iliac vessels, lie on and deepen the brim (fig. 203, p. 179). The *conjugate diameter* is the distance in the middle line from the promontory of the sacrum to the symphysis pubis ; the *transverse diameter*, the width of the brim at its widest part, is nearly an inch more than the conjugate.

FIG. 194.—THE PELVIS AND ITS LIGAMENTS. (*Sappey.*)



1. Lower part of anterior common ligament of vertebræ. 2. Ilio-lumbar ligament. 3. Lumbo-sacral or sacro-vertebral ligament. 4, 4. Anterior sacro-iliac ligament. 5, 5. Great sacro-sciatic ligament. 6. Small sacro-sciatic ligament. 7. Fibro-cartilage of symphysis.

The *outlet* is formed by: (1) The subpubic arch and subpubic ligament; (2) the ischial tuberosities; (3) the great sacro-sciatic ligaments with the tip of the coccyx between them. The outlet, which bounds the perineum, is diamond-shaped.

The *pelvic wall* is much deeper behind, where it is formed by the anterior surface of the sacrum, than in front, where it is formed by the symphysis pubis and body of the pubis. The os innominatum, below the line of the brim, forms its deep lateral wall. The obturator foramen is closed by the obturator membrane. The small sacro-sciatic ligaments and pyriform muscle fill up the interval formed in the lateral wall by the great sacro-sciatic foramen. One of the muscles of the thigh, the obturator internus, arises within the pelvis, and this, with its sheath, the obturator fascia, plays an important part in forming the inner lining of the antero-lateral wall of the pelvis (fig. 199, p. 173). It will be examined presently.

The **floor of the pelvis** is formed by three muscles and their sheaths (fig. 200, p. 174) ; first and most, the levator ani, secondly the coccygeus, and thirdly the constrictor urethræ. An understanding of the attachments and disposition of these three muscles, and of the obturator internus, is the first essential if the student would have a clear conception of how the pelvic viscera are fixed and contained. Some dissection, however, is necessary before they can be examined. The peritoneum, too, must be examined.

Dissection.—To allow a more free access to the cavity of the pelvis, a horizontal section is to be made by a saw, along the brim of the pelvis (fig. 200, p. 174). The edge of the brim, with the iliac fossæ and base of the sacrum, are to be cut away. Care must be taken not to let the saw sink to the level of the great sacro-sciatic notch, otherwise the sacrum will become detached.

Pelvic Peritoneum.—It is composed of the following parts:

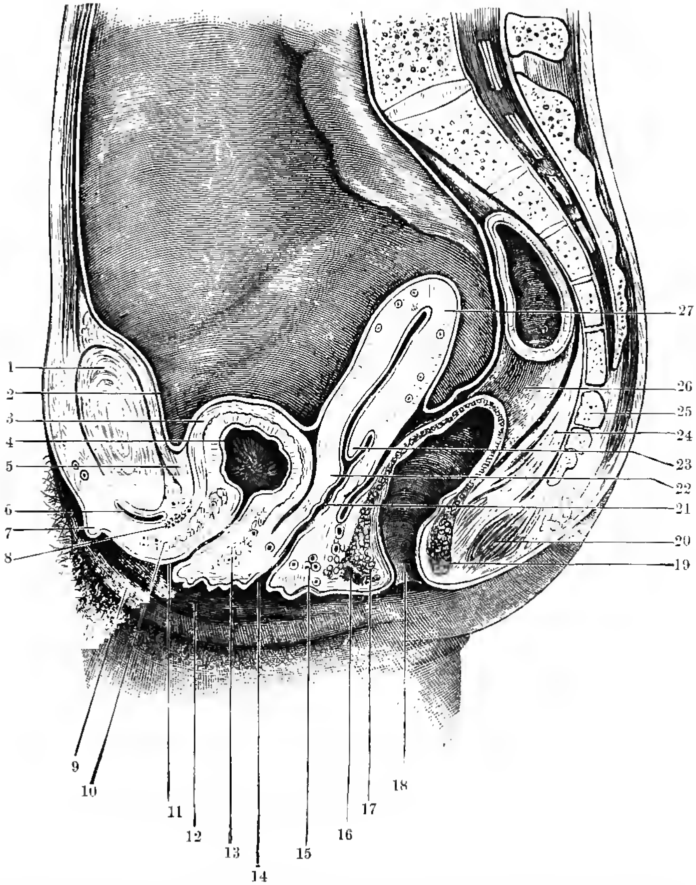
(1) Rectal.
(2) Vesical.
(3) Uterine.
(4) Parietal.

(1) **Rectal.**—The first stage of the rectum (fig. 195) is completely enclosed by peritoneum ; the meso-rectum is attached in front of the upper three vertebræ of the sacrum, towards their left side. At their sacral attachment, the layers of the meso-rectum open out and become continuous with the parietal peritoneum covering the sacrum and lateral pelvic walls. The rectal peritoneum, which is firmly attached, covers less and less of the rectum as it goes down ; the second stage of the rectum is only covered in its upper half, and only on the anterior surface of that half.

(2) **Vesical.**—The empty bladder presents a flat triangular

upper or abdominal surface, which becomes convex and ascends in the abdomen when the bladder is full (fig. 214, p. 197). The apex of the abdominal surface is at the pubis, the base behind.

Fig. 195.—Section of the female pelvis. (*After Henle.*)



1. Symphysis. 2. Peritoneum. 3. Vesical wall. 4. Cavity of bladder. 5. Prevesical fat. 6. Dorsal vein. 7. Clitoris. 8. Deep transversus perinæi. 9. Labium majus. 10. Unstriped muscular fibre. 11. Urethra. 12. Labium minus. 13. Unstriped muscular fibre. 14. Vaginal orifice. 15. Vessels. 16. Part of external sphincter ani. 17. Internal sphincter ani. 18. Anus. 19. Internal sphincter ani. 20. External sphincter ani. 21. Vagina. 22. Anterior lip. 23. Posterior lip of os uteri. 24. Recto-coccygeal muscle. 25. Coccyx. 26. Rectum. 27. Uterus.

The peritoneum covers and is firmly adherent to this surface. From the margins of the apex the peritoneum is reflected on the urachus to the anterior abdominal wall above the symphysis. The peritoneal fold thus reflected on the urachus forms the *anterior false ligament* or urachal fold of the bladder. It is attached by loose sub-peritoneal tissue to the upper border of the symphysis and the abdominal wall. The surgeon avails himself of its loose attachment in removing stones from the bladder by the supra-pubic operation (fig. 208A).

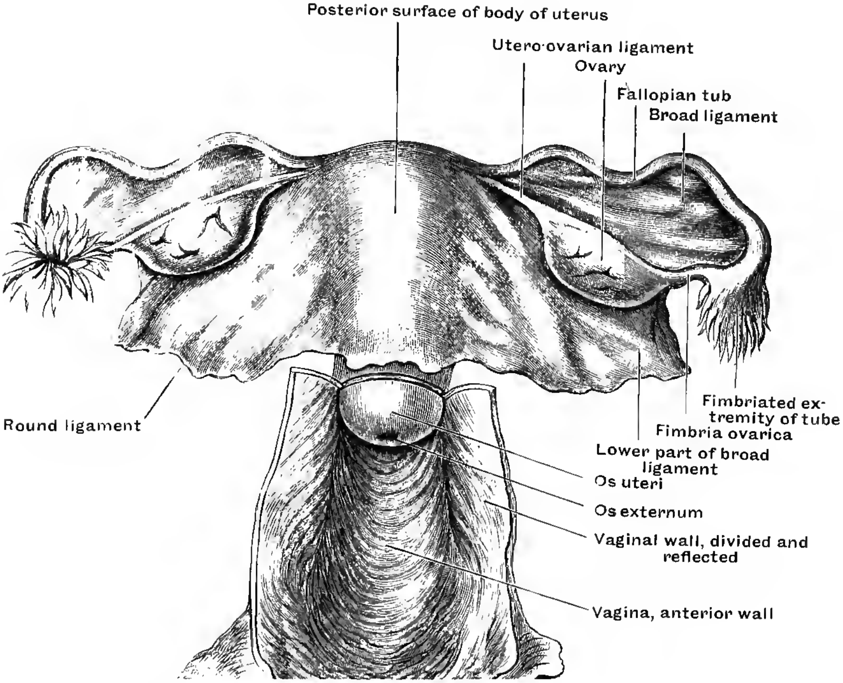
From the lateral margin of the peritoneal or abdominal surface of the bladder, the peritoneum is reflected on loose sub-peritoneal tissue to the lateral wall of the pelvis and over the obliterated hypogastric arteries. These lateral reflections form the *lateral false* ligaments of the bladder. In the female they are continuous behind with the broad ligament of the uterus (fig. 197). The vesical peritoneum turns round and covers the posterior edge of the base of the bladder. In the female it passes from the posterior margin of the base of the bladder to the neck of the uterus (fig. 195); in the male it becomes continuous with the rectal peritoneum at the bottom of the recto-vesical pouch (fig. 208A, p. 188).

POSTERIOR FALSE LIGAMENTS OF THE BLADDER (RECTO-VESICAL FOLDS).—These exist only in the male. They are folds of peritoneum reflected from the lateral angles of the triangular abdominal surface of the bladder to the postero-lateral wall of the pelvis. On the wall of the pelvis the peritoneum of the posterior false ligaments becomes continuous with the parietal peritoneum. In front they are continuous with the lateral false ligaments. The vas deferens descends beneath the lateral parietal peritoneum and crosses over the ureter within the parietal attachments of the posterior false ligaments (fig. 207, A, p. 185).

(3) **Uterine** (fig. 195).—The peritoneum adheres firmly to the uterus. It covers the fundus, the anterior surface of the body and upper part of the cervix, and becomes continuous with the vesical. It covers the posterior aspect of the body and cervix and half an inch of the posterior wall of the vagina. There it becomes continuous with the rectal and forms the bottom of Douglas's pouch. This, it will be seen, can be tapped and examined from the vagina.

BROAD LIGAMENTS OF THE UTERUS (fig. 196).—The peritoneum does not cover the lateral margins of the uterus. There the visceral uterine peritoneum is reflected to the lateral wall of the pelvis as a deep fold to which the name of broad ligament is given. It supports the uterus and appendages and conveys the uterine vessels and nerves. The *anterior layer* of the broad ligament is shallow and becomes continuous in front with the lateral false ligament of the bladder. The anterior layer is raised by the *round ligament of the uterus* as it proceeds to the internal abdominal ring (fig. 197). The *posterior layer* is deep; it is wide at its upper free margin, in which the *Fallopian tube* is contained; below it ends between the neck of the uterus and the lateral pelvic wall in an angle. The *ovary* is attached to the posterior layer of the broad ligament as that layer is reflected backwards on the lateral wall of the pelvis. The round ligament of the ovary, which connects it to the uterus, raises the posterior layer into a slight fold.

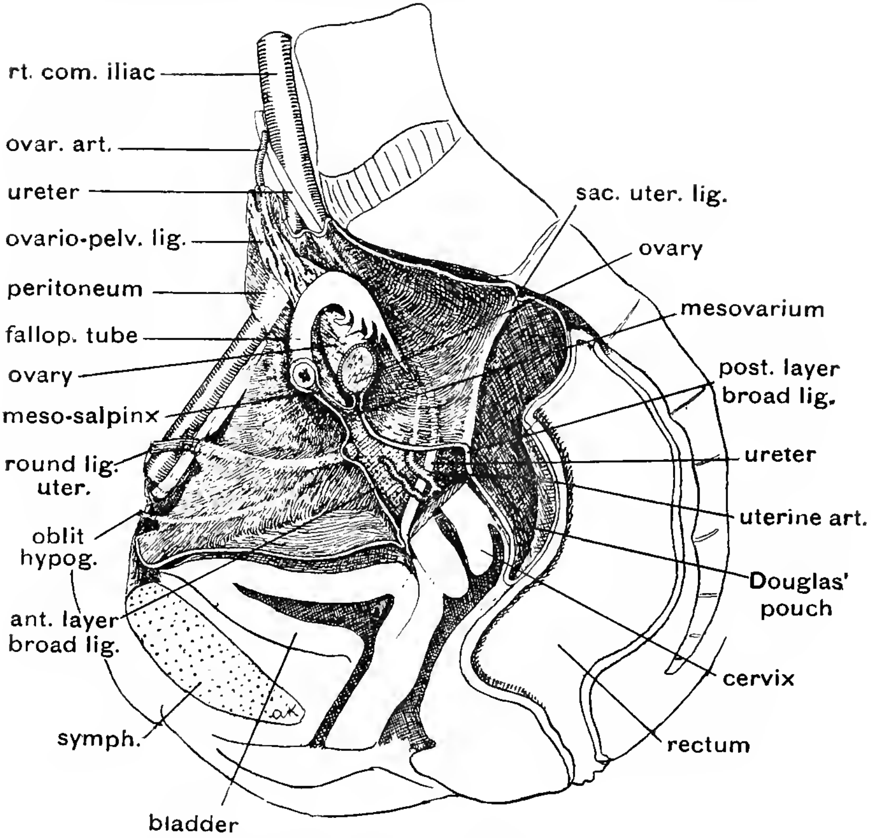
Fig. 196.—The broad ligament of the uterus from behind. (*From Morris's 'Anatomy.'*)


Posterior surface of body of uterus
Utero-ovarian ligament
Ovary
Fallopian tub
Broad ligament
Round ligament
Fimbriated extremity of tube
Fimbria ovarica
Lower part of broad ligament
Os uteri
Os externum
Vaginal wall, divided and reflected
Vagina, anterior wall

The ovarian vessels enter the two layers of the pelvic attachment of the broad ligament. As they cross the brim and enter, they give rise to the *ovario-pelvic* or *infundibulo-pelvic* fold (fig. 197).

The ureter courses down beneath the parietal peritoneum on the lateral pelvic wall, and enters the lower or *cervical* part of the broad ligament (fig. 197).

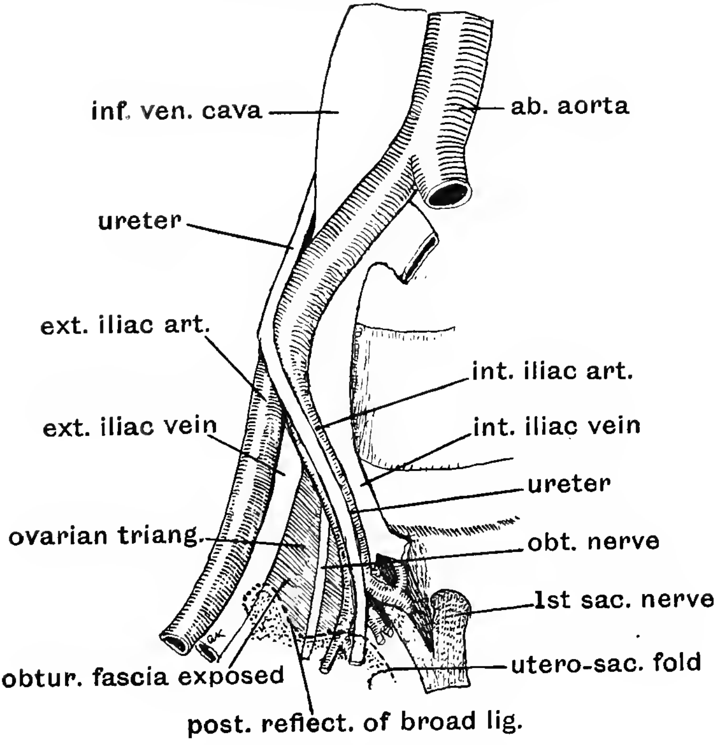
Fig. 197.—A VERTICAL SECTION OF THE BROAD LIGAMENT OF THE UTERUS, SHOWING THE REFLECTION OF ITS ANTERIOR AND POSTERIOR LAYERS ON THE LATERAL WALL OF THE PELVIS.



There is an abundance of loose connective sub-peritoneal tissue between the layers of the broad ligament. Indeed, only the *visceral* pelvic peritoneum is firmly attached. The reflections of the parietal peritoneum to the viscera are loosely bound and can be easily displaced in operations. The pelvic sub-peritoneal tissue is of great pathological interest, for in it inflammations are liable to occur, and the student will see how easily pus may spread beneath the peritoneum in the lateral walls of the pelvis and mount upwards to the iliac fossæ and inguinal regions. The tissue in the cervical part of the broad ligament can be palpated from the vagina.

UTERO-SACRAL LIGAMENT (fig. 197).—Behind the broad ligament, and continuous with its posterior layer, this fold of peritoneum will be seen reflected on each side from the cervix of the uterus to the lateral wall of the pelvis and the sacrum. It contains within it non-striated muscular fibres. It supports and fixes the uterus.

FIG. 198.—DIAGRAM OF THE OVARIAN TRIANGLE.



(4) **Parietal.**—The parietal peritoneum covers the lateral and posterior walls of the pelvis. On the sacrum it is continuous with the meso-rectum and covers the three upper sacral vertebræ, sacral vessels and upper sacral nerves and ganglia, and upper part of the pyriformis. On the lateral wall it is continuous with the ligaments of the uterus in the female and

false ligaments of the bladder in the male. Laterally it covers the internal iliac vessels, ureter, vas deferens, and obliterated hypogastric arteries. The ureter lies on the internal iliac artery.

Ovarian Triangle (fig. 198).—On the lateral wall, the parietal peritoneum covers a triangle of some importance. The apex of the ovarian triangle lies between the internal and external iliac arteries ; the external iliac artery forms its upper boundary ; the internal iliac artery and ureter form the lower or posterior boundary. The pelvic attachment of the posterior layer of the broad ligament forms its anterior boundary or base. The ovary lies on the peritoneum over this triangle (fig. 197). Occasionally the peritoneum over it is found depressed into a well-marked fossa—the *fossa ovarii.*

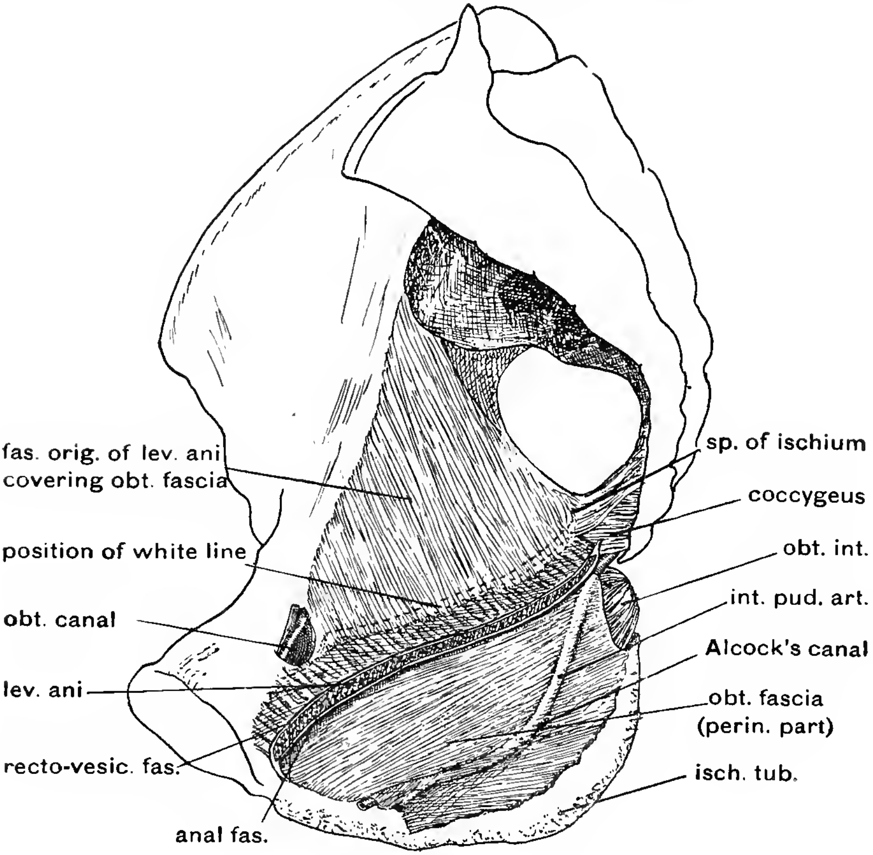
The student is now to return to the formation of the pelvic walls and floor.

Obturator Internus.—It is not possible for him at this stage to completely expose this muscle. The origin of the muscle should be marked out on a dried pelvis and its position in the lateral wall of the pelvis thus studied. Its insertion, nerve supply, and action are described in the dissection of the thigh. It *arises* from the inner surface of the obturator membrane, from the bony margin of the obturator foramen and from the surface of the hip-bone above and behind the foramen, as far as the great sacro-sciatic notch and ilio-pectineal line (fig. 124). Leaving the pelvis by the lesser sciatic foramen, it winds sharply round the ischium at its exit from the pelvis. It is smooth and tendinous on its deep surface, which glides over the cartilage covering the lesser notch on the ischium. A bursa intervenes.

Obturator Fascia (fig. 199).—The pelvic surface of this muscle is furnished with an extremely strong sheath, the obturator fascia. The fascia is attached at the circumference of the origin of the muscle, viz. (1) along the brim of the pelvis, (2) to the lower margin of the obturator canal, (3) to the posterior or inner margin of the pubic arch and ischial tuberosity, (4) to the margins of the small sacro-sciatic foramen where the tendon escapes, (5) to the anterior margin of the sacro-sciatic notch. The sheath or fascia is only developed on the pelvic aspect of the muscle; on its attached surface, the sheath is formed by the pelvic periosteum and obturator membrane.

White Line (fig. 199).—When the peritoneum and subperitoneal tissue are picked off, the lateral pelvic wall and the obturator fascia exposed, a white fibrous thickening (the white line) on the fascia will be seen running from the posterior aspect of the pubis to the ischial spine. Near it the levator ani arises. The white line divides the obturator fascia into two parts : a part above the white line, *supra-linear*, and a part below the white line, *infra-linear* or perineal. The infra-linear part was already seen, and may again be examined, in the outer wall of the ischio-rectal fossa (fig. 126, p. 13). It lies outside

FIG. 199.—THE OBTURATOR FASCIA. (*After P. Thompson.*)



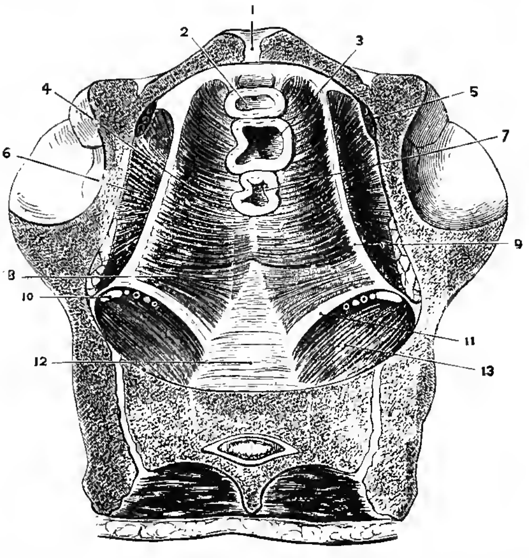
the floor of the pelvis, which is formed mainly by the levatores ani. The obturator fascia forms part of the pelvic fascia.

Pelvic Floor.—The structures entering into its formation on each side are (fig. 200):

(1) Levator ani and its sheath (fig. 200, 4). The sheath is composed of two layers—the recto-vesical fascia on the pelvic surface of the muscle, and the anal fascia on the perineal surface (fig. 201). (P. Thompson.)

(2) The constrictor urethræ and its sheath, the triangular ligament (fig. 191, p. 161).

FIG. 200.—THE FLOOR OF THE FEMALE PELVIS. (*Savage.*)



1. Symphysis pubis. 2. Section of bladder. 3. Section of vagina. 4. Levator ani muscle. 5. Obturator vessels. 6. Obturator internus muscle. 7. Section of rectum. 8. Coccygeus muscle. 9. 'White line' of pelvic fascia. 10. Sciatic and pudic vessels and nerves. 11. Lesser sacro-sciatic ligament. 12. Front of sacrum. 13. Pyriformis muscle.

(3) The coccygeus muscle and its sheath. The *coccygeus* is a thin triangular muscular sheet, lying in the same plane as the levator ani (fig. 200, 8). It *arises* from the inner aspect of the ischial spine and is *inserted* to the side of the coccyx and lowest piece of the sacrum.

The floor is a funnel-shaped fibro-muscular diaphragm, suspended from the sides of the pelvis and stretching across the outlet of the pelvis (fig. 201). It sustains the pelvic organs. The anal canal, the urethra, and in the female the vagina, perforate the floor and open on the perineum (fig. 200).

Levator Ani.—This muscle, which, with its sheath, forms with the muscle of the opposite side the greater part of the pelvic floor, is the key to the arrangement and relationships of the pelvic viscera. With the help of preparations and the use of the dried pelvis, the student should try to form a true conception of this muscle before he actually commences its dissection.

ORIGIN AND INSERTION (figs. 199 and 200).—(1) The *anterior fibres* arise from the pelvic aspect of the pubis, near the symphysis. The pubic fibres of the two sides have a slight interval between them in which the apex of the prostate rests. They sweep past the side of the prostate, forming a bed for it. Some of the fibres end in the capsule of the prostate, some end in the central point of the perineum and side of the anal canal, but most sweep backwards to the ano-coccygeal ligament and coccyx.

(2) The *posterior fibres* arise from the inner aspect of the spine of the ischium, or rather above it, and pass to the side of the coccyx and ano-coccygeal ligament on the perineal aspect of the anterior fibres.

(3) The *middle fibres*, filling the interval between the anterior and posterior fibres, rise from the white line and from the obturator fascia above the white line and pass to the side of the anal canal, ano-coccygeal ligament, and side of the coccyx.

At their insertions the two muscles meet in the middle perineal line, between the coccyx behind and the central tendinous point in front. The anal canal perforates between them. They support and surround the anal canal, mixing with the external sphincter.

NERVE SUPPLY.—From the fourth sacral by its perineal branch and also by a separate muscular branch (fig. 192, 21, p. 162).

ACTION.—Its action must be considered with the other compressors of the abdominal cavity, viz. the diaphragm and muscles of the abdominal wall. In defæcation all three sets are used. The compressor action of the levator ani is exerted on the rectum, bladder, and vesiculæ seminales. It maintains the floor of the pelvis. In the female, it has to allow the passage of the child at birth.

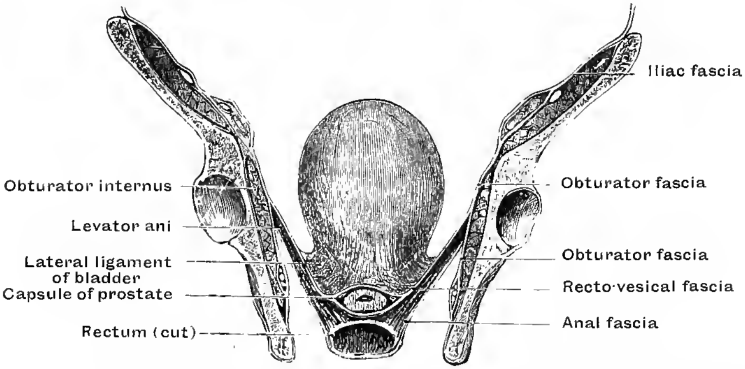
RELATIONSHIPS.—On its upper surface, from before backwards, there rest in the male (Plate XLI, fig. 2, p. 158): (1) The prostate; (2) the lower part of the lateral walls of the bladder; (3) the non-peritoneal stage of the rectum—lower part of the second stage (fig. 208A, p. 188); (4) the visceral branches of the internal iliac vessels; (5) the pelvic plexus of nerves.

In the female (fig. 200): (1) The neck and lateral walls of the bladder; (2) the vagina and bases of the broad ligaments; (3) the rectum (as in the male); (4) vessels and nerves as in the male, the uterine taking the place of the prostatic.

The *lower surface* of the muscle forms the inner wall of the ischio-rectal fossa (fig. 201).

Sheath of the Levator Ani.—The *upper or pelvic aspect* of the muscle is covered and strengthened by a fibrous sheath, to which the name of *recto-vesical* fascia is given. It can be seen by raising the sub-peritoneal tissue and viscera. The fasciæ meet in the middle line, stretching from the white line of one side to the white line of the other (fig. 200). Behind it is continuous with the sheaths on the pelvic aspect of the coccygeus and pyriformis.

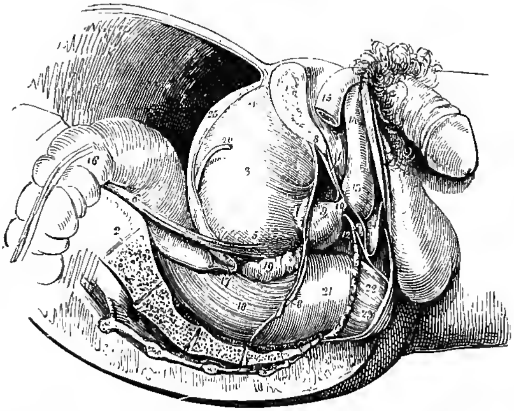
FIG. 201.—A DIAGRAMMATIC SECTION ACROSS THE PELVIC FLOOR, VIEWED FROM THE FRONT. (*Wilson.*)



The sheath on the *perineal aspect* has been examined in the dissection of the ischio-rectal fossæ. It is thin, and known as the *anal fascia*. In front it is continuous with the sheaths of the obturator internus and constrictor urethræ (triangular ligament).

Capsules of the Viscera (see figs. 201 and 202).—(1) PROSTATIC. The prostate especially has a thick, fibrous capsule. The gland rests on the upper aspect of the levator ani muscle; the capsule of the prostate is therefore continuous with, and forms part of, the upper sheath of the muscle, the recto-vesical fascia (see fig. 202, 9). If the bladder be pushed backwards from the pubis and the prostate exposed behind the symphysis, the capsule will be seen. Thick capsular bands pass to the symphysis and retain the prostate firmly in position. These are the pubo-prostatic ligaments (fig. 189, 7, p. 155) or anterior true ligaments of the bladder. The dorsal vein of the penis pierces the triangular ligament and ends in the prostatic plexus of veins which lies in the capsule of the prostate.

Fig. 202.—The viscera of the male pelvis exposed from the right side. (*Wilson.*)



1. Divided surface of the os pubis. 2. Divided surface of the sacrum. 3. Body of the bladder. 4. Apex of bladder; from the apex is seen passing upwards the urachus. 5. Base of the bladder. 6. Ureter. 7. Neck of the bladder. 8, 8. Pelvic fascia: the fibres immediately above 7 are given off from the pelvic fascia, and represent the anterior ligaments of the bladder. 9. Prostate gland. 10. Membranous portion of the urethra. 11. Triangular ligament. 12. One of Cowper's glands lying beneath the membranous portion of the urethra. 13. Bulb of corpus spongiosum. 14. Body of corpus spongiosum. 15. Right crus penis. 16. Upper part of first portion of the rectum. 17. Recto-vesical fold of peritoneum. 18. Second portion of rectum. 19. Right vesicula seminalis. 20. Vas deferens. 21. The rectum covered by the descending layer of the pelvic fascia (sheath of rectum), just as it is making its bend backwards to constitute the anal canal. 22. Part of the levator ani muscle investing the lower part of the rectum. 23. External sphincter ani. 24. Interval between Colles' fascia and the anterior layer of the triangular ligament; they are seen to be continuous beneath the figure.

(2) Vesical.—The neck and lateral walls of the bladder have a fibrous capsule (fig. 201). These parts lie on the levatores ani. Their sheaths become blended, the *lateral true ligaments* of the bladder being thus formed.

(3) Rectal.—The non-peritoneal surface of the rectum has a loose fibrous capsule, continuous with the pre-sacral tissue and sheath of the pyriformis (fig. 202, 21). Where the rectum reaches and lies on the levatores ani the rectal sheath becomes continuous with their upper sheath (recto-vesical fascia).

(4) VAGINAL.—The vaginal fibrous sheath is also continuous with that of the levator ani, on which it rests.

(5) VESICULAR.—The termination of the vas and the vesiculæ seminales are surrounded by dense fibrous tissue, forming the vesicular capsule. These structures are situated between the rectum and bladder. Hence the sheath of these organs is continuous with those of the rectum and bladder, and, through them, with the upper sheath of the levator ani of each side.

Pelvic Fascia.—This fascia is composed of:

(1) The fibrous capsules of the pelvic viscera.

(2) The sheaths of the levator ani and coccygeus (recto-vesical and anal fasciæ).

(3) The sheath of the obturator internus (obturator fascia).

(4) The sheath of the constrictor urethræ (triangular ligament).

(5) The sheath on the pelvic aspect of the pyriformis. The sacral plexus lies outside this sheath; the internal iliac vessels lie inside it (*i.e.* on its rectal aspect).

The pelvic fascia strengthens the pelvic floor; it binds the structures together; it conveys the arteries and nerves, veins and lymphatics. It limits the spread of pus.

Blood Supply of the Pelvic Viscera and Walls (see fig. 203 and Plate XLII).—(1) The internal iliac vessels—these are the chief; (2) the ovarian vessels; (3) the superior hæmorrhoidal; (4) the middle sacral.

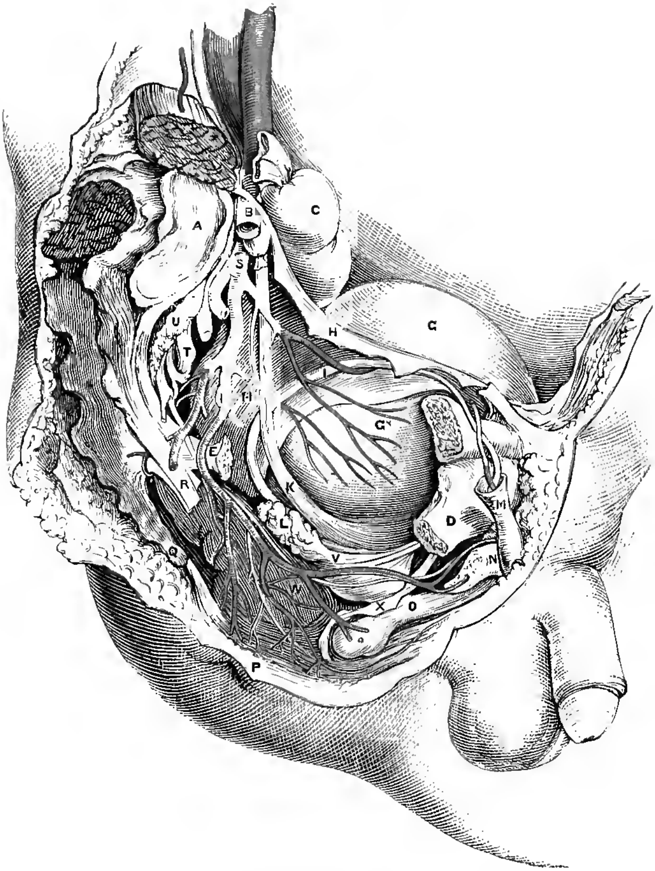
Internal Iliac Artery (fig. 203, 12).—The internal iliac artery is a short trunk, one inch and a half long, which extends from the bifurcation of the common iliac artery, opposite the lumbo-sacral articulation, to the upper part of the great sacro-sciatic foramen, where it divides into anterior and posterior divisions. In the adult, the internal iliac artery is smaller than the external iliac, but in the fœtus it is the larger artery, and is continued as the hypogastric.

RELATIONS.—It is covered *in front* by peritoneum, beneath which the ureter descends in front of the artery (fig. 198). *Behind*, it rests against the ala of the sacrum, but is separated from it by the lumbo-sacral cord, obturator nerve, and internal iliac vein.

Hypogastric Arteries.—Until the time of birth the internal iliac artery gave off branches in the pelvis, and was continued on each side to the umbilicus and placenta as the hypogastric or umbilical arteries. These now remain as cords, which were seen

PLATE XLII.

THE DISTRIBUTION OF THE INTERNAL ILIAC ARTERY.



A. Sacrum. B. External iliac artery. C. Upper end of rectum. D. Ramus of pubes. E. Spine of ischium (cut off). G. Bladder covered by peritoneum. G×. Bladder uncovered by peritoneum. H. Peritoneum reflected from side of bladder. I. Vas deferens. K. Ureter. L. Vesicula seminalis. M. Spermatic cord. N. Crus penis. O. Urethra. o. Bulb. P. Sphincter ani. Q. Coccyx. R. Great sacro-sciatic ligament. S. Internal iliac artery. T. Sacral nerves. U. Pyriformis muscle. V. Internal pudic artery. W. Levator ani muscle. X. Triangular ligament (cut).

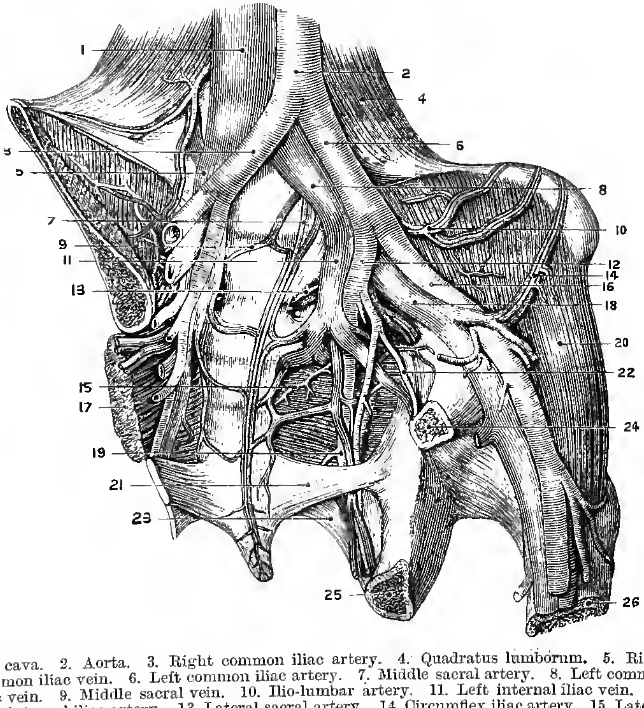
to lie under the peritoneum by the side of the bladder and giving rise to peritoneal folds on the anterior abdominal wall (fig. 143, p. 44).

Branches of the Internal Iliac Artery

I. **From the Posterior Division** (fig. 203).—

(*a*) The gluteal, already traced in the gluteal region.
(*b*) Ilio-lumbar, traced in the iliac fossa and lumbar region.
(*c*) Lateral sacral (2).

FIG. 203.– THE INTERNAL ILIAC VESSELS. (*Bonamy and Beau.*)



1. Vena cava. 2. Aorta. 3. Right common iliac artery. 4. Quadratus lumborum. 5. Right common iliac vein. 6. Left common iliac artery. 7. Middle sacral artery. 8. Left common iliac vein. 9. Middle sacral vein. 10. Ilio-lumbar artery. 11. Left internal iliac vein. 12. Left internal iliac artery. 13. Lateral sacral artery. 14. Circumflex iliac artery. 15. Lateral sacral artery. 16. Left external iliac artery. 17. Pyriformis. 18. Left external iliac vein. 19. Pudic vessels. 20. Ilio-psoas. 21. Small sacro-sciatic ligament. 22. Obturator artery. 23. Great sacro-sciatic ligament. 24. Horizontal ramus of pubes. 25. Ischium. 26. Femur.

(*a*) The GLUTEAL ARTERY, the largest branch of the internal iliac, passes between the lumbo-sacral cord and first sacral nerve, and leaves the pelvis by the upper part of the great sciatic notch to reach the gluteal region (fig. 198).

(*b*) The ILIO-LUMBAR ARTERY passes upwards and outwards, lying usually between the obturator nerve and lumbosacral cord. It disappears under the edge of the psoas, where it divides into a lumbar and an iliac branch (fig. 203, 10).

(*c*) The LATERAL SACRAL ARTERIES are usually two in number, superior and inferior. The *superior* enters the first sacral foramen; the *inferior* passes down on the pyriformis external to the anterior sacral foramina. It gives off branches to the muscle and into the foramina, and terminates at the lower end of the sacrum by anastomosing with the middle sacral artery (fig. 203, 13, 15).

II. **From the Anterior Division** (Plate XLII).—

(*a*) The obliterated hypogastric and superior vesical artery.
(*b*) Inferior vesical.
(*c*) Prostatic or vaginal.
(*d*) Uterine.
(*e*) Middle hæmorrhoidal.
(*f*) Obturator, already traced to the thigh.
(*g*) The sciatic, traced to the back of the hip-joint.
(*h*) Internal pudic, traced to the perineal region and external genital organs.

(*a*) The SUPERIOR VESICAL ARTERY is given off from the unobliterated portion of the hypogastric artery. It gives off two or three branches to the side of the bladder (Plate XLII, G).

(*b*) The INFERIOR VESICAL ARTERY passes to the base and neck of the bladder, and gives branches to the vesiculæ seminales and prostate. It gives off the artery to the vas. This branch ascends on and accompanies the vas almost to the testicle. It anastomoses with the cremasteric and spermatic vessels.

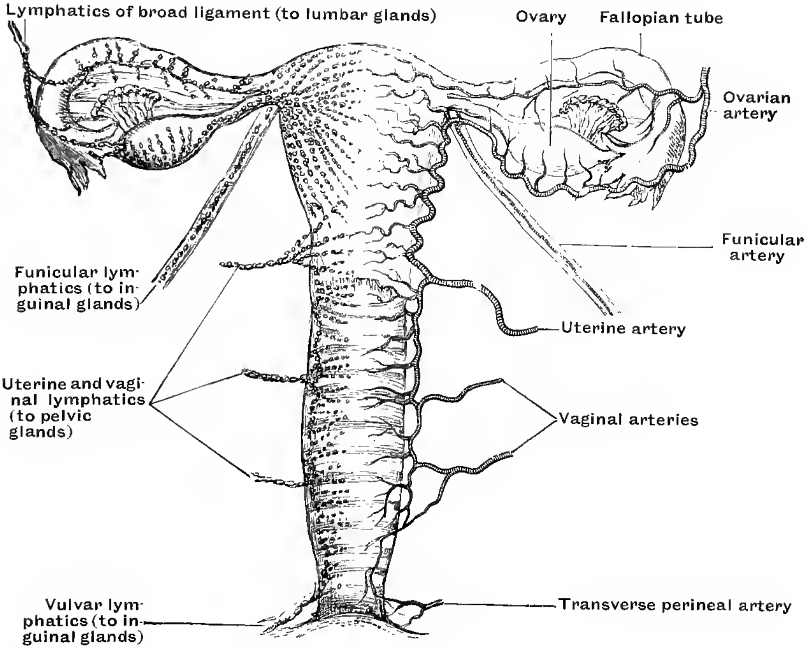
Occasionally an *accessory pudic* artery arises from it. Such a vessel passes by the side of the prostate, perforates the triangular ligament, and ends as the dorsal artery of the penis. The prostatic artery arises from the inferior vesical as a rule.

(*c*) The MIDDLE HÆMORRHOIDAL ARTERY passes to the side of the rectum and anastomoses with the superior and inferior hæmorrhoidal arteries (Plate XLII, below H). It is a small and irregular vessel.

(*d*) The OBTURATOR ARTERY passes along the lateral wall of the pelvis below the obturator nerve, and leaves the pelvis with the nerve through the upper part of the obturator foramen (fig. 203, 22). Within the pelvis it gives off *iliac* branches to the iliac fossa, and a *pubic* branch which anastomoses on the back of the pubis with the deep epigastric artery (see also p. 40).

(*e*) The UTERINE ARTERY springs from the anterior division and immediately enters the tissue at the base of the broad ligament (fig. 197). It often arises with the middle hæmorrhoidal. It loops over the ureter and reaches the neck of the uterus, where it turns upwards on the lateral margin of the uterus between the layers of the broad ligament, and anastomoses with the ovarian artery. Before it turns upwards it gives off a vaginal branch which ramifies on the side of the vagina (fig. 204).

FIG. 204.—DIAGRAM OF THE ARTERIES AND LYMPHATICS OF THE FEMALE GENERATIVE ORGANS. (*From Morris's 'Anatomy.'*)


Lymphatics of broad ligament (to lumbar glands)
Ovary
Fallopian tube
Ovarian artery
Funicular artery
Funicular lymphatics (to inguinal glands)
Uterine artery
Uterine and vaginal lymphatics (to pelvic glands)
Vaginal arteries
Vulvar lymphatics (to inguinal glands)
Transverse perineal artery

(*f*) The INTERNAL PUDIC ARTERY passes on the surface of the pyriformis to the lower part of the great sciatic foramen, through which it enters the gluteal region. There it crosses the spine of the ischium and enters the outer wall of the ischio-rectal fossa, by passing through the lesser sciatic foramen (Plate XLII).

(*g*) The Sciatic Artery, rather larger than the pudic, lies behind and external to that vessel. It enters the gluteal region with the sacral nerves below the pyriformis (Plate XLII).

Veins of the Pelvis (see fig. 205).—The sciatic, internal pudic, prostatic, vesical, and middle hæmorrhoidal veins unite on the lateral wall of the pelvis and form the internal iliac vein, internal to and rather behind the anterior division of the internal iliac artery. The gluteal, lateral sacral, and obturator veins join the trunk vein thus formed. The ilio-lumbar, part of the lateral and middle sacral veins, join the common iliac.

Prostatic Plexus.—The prostate is surrounded by a close plexus of veins, which when wounded gives rise to much hæmorrhage. The dorsal vein of the penis perforates between the subpubic and the triangular ligaments and ends in the plexus. Most of the vesical veins, forming a plexus round the neck of the bladder, also end in it. The veins leaving the prostatic plexus pass on each side of the rectum and are joined there by the middle hæmorrhoidal veins; they then pass on to the lateral wall of the pelvis, where they join with the pudic and sciatic to form the internal iliac vein.

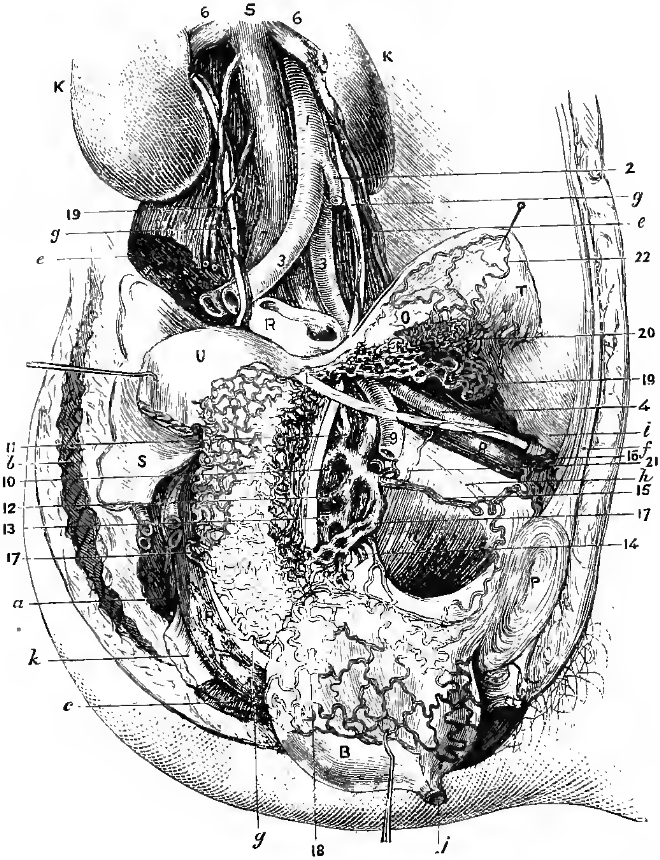
The uterine veins join the internal iliac vein; they are frequently large and plexiform (fig. 205). The ovarian veins pass to the renal vein on the left side, and inferior vena cava on the right.

Lymphatics of the Pelvis.—From a clinical point of view, these are of the greatest importance; pathological disturbances are so often spread by them.

Internal Iliac Glands.—Into this group of glands nearly all the lymphatics of the pelvis pass. The glands lie in the sub-peritoneal tissue in the angle between the external and internal iliac arteries (ovarian or iliac triangle) (fig. 198, p. 171). Some lie among the branches of the anterior division of the artery. In the female they are partly situated in the parietal reflection of the broad ligament. The lymphatics from the second stage of the rectum, anal canal, vesiculæ seminales, prostate, bladder, body of the uterus, upper part of the vagina, pelvic wall, gluteal, sciatic and perineal regions, end in this group. The efferent vessels of the internal iliac glands pass to the chain on the outer side of the common iliac artery.

The *ovarian lymphatics* pass to the lumbar glands; the lymphatics from the fundus and appendages of the uterus accompany them (fig. 204).

Fig. 205.—Side view of the female pelvis, showing the distribution of the veins. (*Savage.*)

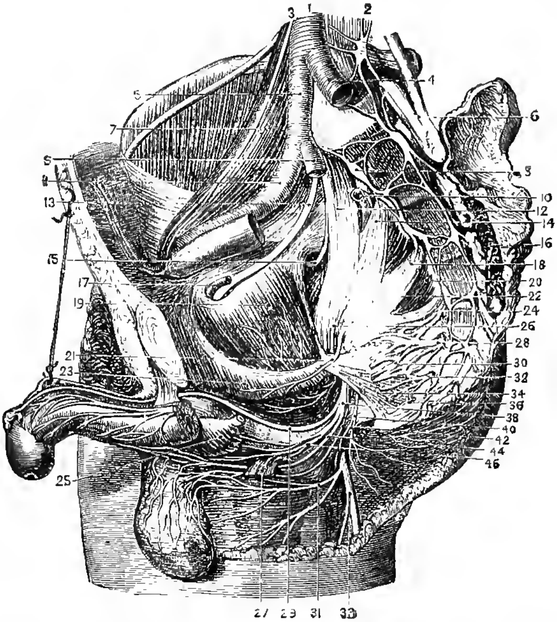


B. Bladder (turned down). R. Rectum. L. Round ligament. U. Uterus. O. Ovary. V. Vagina. S. Sacro-iliac synchondrosis. K. Kidney. T. Fallopian tube. P. Pubic symphysis. *a.* Pyriformis muscle (cut). *b.* Gluteal muscles. *c.* Coccygeus muscle. *d.* Obturator internus. (Other references in text.)

The lymphatics of the first stage of the rectum, and some from the second stage, pass to the glands in the sacral attachment of the meso-rectum. Hence both sacral and iliac glands may be attacked in cancer of the rectum.

Nerve Supply of the Pelvic Viscera.—PELVIC PLEXUS. This should be looked for now. It corresponds to the solar plexus in the abdomen and is part of the sympathetic system. Through it the pelvic viscera—rectum, bladder, uterus, &c.—are supplied with sensory, motor, and vaso-motor nerves. It lies in the sub-peritoneal and fibrous tissue on the postero-lateral wall of the pelvis, on each side of the second stage of the rectum and amongst the visceral branches of the internal iliac vessels. There is a plexus on each side.

FIG. 206.—THE NERVES OF THE PELVIS. (*Hirschfeld and Leveillé.*)



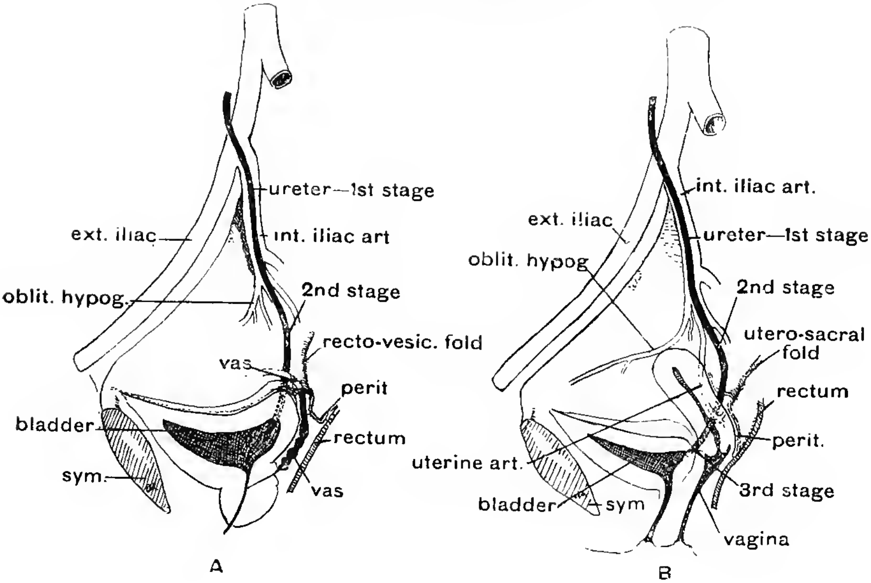
1. Abdominal aorta. 2. Gangliated cord of sympathetic (left side). 3. Genito-crural nerve. 4. Left common iliac artery. 5. Right common iliac artery. 6. Left lumbo-sacral cord. 7. Psoas muscle. 8. Gangliated cord of sympathetic (right side). 9. Internal iliac artery (cut). 10. Gluteal artery (cut). 11. Right external iliac artery. 12. Right lumbo-sacral nerve. 13. Obturator nerve. 14. First sacral nerve. 15. Gluteal nerve. 16. Pyriformis of left side (cut). 17. Obturator artery. 18. Second sacral nerve. 19. Obturator internus. 20. Pyriformis of right side. 21. Nerve to levator ani. 22. Sacral plexus. 23. Levator ani (cut). 24. Third sacral nerve. 25. Bulb of urethra covered by accelerator urinæ. 26. Nerve to obturator internus. 27. Transversus perinæi (cut). 28. Fourth sacral nerve. 29. Dorsal nerve of penis. 30. Visceral branches (cut). 31. Inferior pudendal nerve. 32. Fifth sacral nerve. 33. Small sciatic nerve. 34. Coccygeus muscle. 36. Sixth or coccygeal nerve. 38. Internal pudic nerve. 40. Inferior hæmorrhoidal nerve. 42. Posterior superficial perineal nerve. 44. Anterior superficial perineal nerve. 46. Deep perineal nerves to bulb and muscles.

It is formed thus: (1) The *descending branches of the hypogastric plexus* (fig. 175, p. 121). Through these, motor fibres for the rectum, uterus, and bladder descend from the lumbar ganglia and upper lumbar rami communicantes (of 1st and 2nd lumbar nerves).

(2) *Pelvic splanchnics* join the plexus from the 3rd and 4th sacral nerves. These are known as the nervi erigentes. Through these pass sensory and motor fibres to the bladder, rectum, vagina, uterus and vesiculæ seminales (see fig. 206, 30, visceral branches).

(3) *Nerves from the sacral ganglia* of the sympathetic (fig. 206). There are four ganglia on each side, and a terminal median ganglion in front of the coccyx. The ganglia lie internal to the anterior sacral foramina.

FIG. 207.—DIAGRAMS OF THE PELVIC COURSE OF THE URETER IN THE MALE (A) AND FEMALE (B).



Ureter.—PELVIC STAGE (for lumbar stage see p. 131) is now to be followed.

(1) **In the Male** (fig. 207, A).—(*a*) It rests on the internal iliac artery and its anterior division beneath the peritoneum. (*b*) It enters the posterior false ligament, is crossed by the vas deferens, and ends in the connective tissue between the base of the bladder and rectum. There it enters the bladder.

(2) **In the Female** (fig. 207, B).—(*a*) Iliac stage as in the male. It lies behind and below the ovary. (*b*) It enters the bases of the broad ligament and passes through it obliquely, half an inch distant from the cervix of the uterus. The uterine artery loops over this, its cervical stage. (*c*) It passes between the base of the bladder and roof of the vagina. This is its *vaginal* stage. The ureter is narrowest at its entrance to the bladder. There a stone, which has descended from the kidney, may be arrested. It may be felt through the roof of the vagina.

Vas Deferens (see fig. 148, p. 56).—PELVIC STAGE. This has been traced already from the internal abdominal ring (Plate XLII). It crosses the obliterated hypogastric artery and ureter, and enters the fibrous tissue between the rectum and base of the bladder. The two vasa deferentia lie between the two vesiculæ seminales in this tissue (fig. 189, p. 155).

The Bladder.—This is now to be removed, with the prostate, from the pelvis. The peritoneum is divided at its reflection to the rectum or uterus behind, and to the pelvic walls (lateral false ligaments) at the side. The lateral true ligaments and pubo-prostatic are cut and separated from the sheath of the levator ani. The vesiculæ seminales, vasa deferentia, and ureters are separated from the second stage of the rectum and removed with the bladder and prostate (fig. 208). The pelvic relationships of the bladder and prostate will be then clearly seen.

In the female the bladder has to be separated from the vagina and cervix of the uterus (fig. 195).

SHAPE.—When moderately distended the bladder is somewhat ovoid in shape, its broad part or base being directed downwards and backwards. In the standing posture, its antero-posterior or long axis is almost horizontal, having but a slight upward inclination from base to summit (fig. 208A).

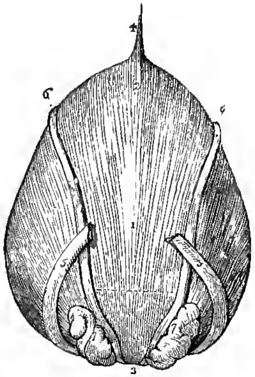
SURFACES.—It presents for examination :

(1) A summit ;
(2) Postero-superior (peritoneal) surface ;
(3) Antero-inferior (pubic) surface ;
(4) Right and left lateral surfaces ;
(5) A neck ;
(6) A base.

The *summit* of the bladder is directed forwards and upwards towards the anterior abdominal wall. It gives attachment to the *urachus*, the fibrous, cord-like remains of the allantoic stalk, which extends towards the umbilicus behind the linea alba. The *postero-superior surface* is covered by peritoneum, and is in relation to the rectum and some coils of small intestine (fig. 208A). The *antero-inferior* or *pubic surface* is not covered by peritoneum, and is separated from the back of the symphysis pubis and puboprostatic ligaments by a quantity of very loose areolar fatty-tissue (fig. 128, p. 17). During distension the upper part of this surface comes in contact with the anterior abdominal wall, and can be punctured above the pubis without injuring the peritoneum, which is lifted away from the abdominal wall by the distended bladder (fig. 128). The *lateral wall* is crossed by the obliterated hypogastric artery and vas deferens (Plate XLII). Above the obliterated artery the bladder is covered by peritoneum, but below that line it lies on the sheaths of the obturator internus and levator ani muscles.

The *neck* or outlet of the bladder is surrounded by the prostate (fig. 208A).

FIG. 208. — POSTERIOR ASPECT OF THE MALE BLADDER. THE SEROUS COVERING IS REMOVED IN ORDER TO SHOW THE MUSCULAR COAT. (*Wilson.*)

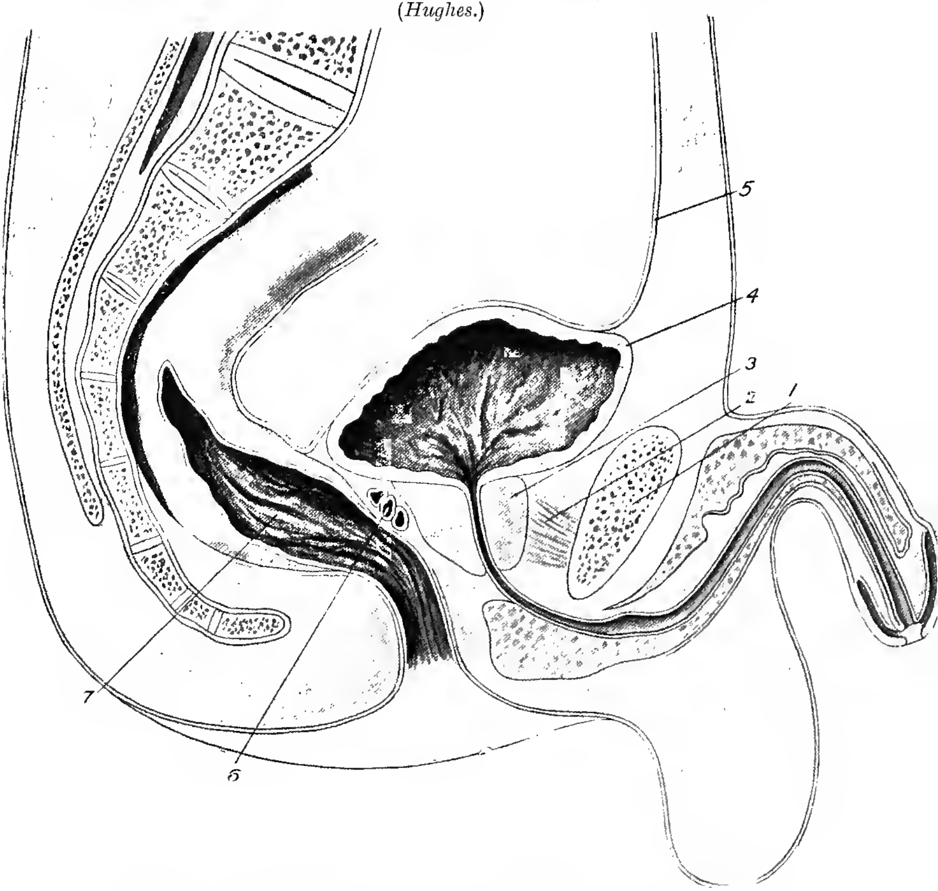


1. Body of the bladder. 2. Apex. 3. Fundus or base. 4. Urachus. 5, 5. Ureters. 6, 6. Vasa deferentia. 7, 7. Vesiculæ seminales. The triangular area, bounded by the vasa deferentia and vesiculæ seminales at either side, a dotted line above, and the figure 3 below, is the space corresponding with the trigonum vesicæ. The dotted line, forming the base of this triangular area, marks the limit of the recto-vesical fold of peritoneum.

The *base* or basal surface of the bladder is directed towards the second part of the rectum, from which it is separated by the vesiculæ seminales, vasa deferentia and their capsular tissue (fig. 208A). The upper portion of the base is related to the deep part of the recto-vesical pouch of peritoneum. The triangular area of the base between the vasa deferentia and the fundus of the recto-vesical pouch, directed against the rectum, is known as the external trigone (fig. 208). Through this area, the bladder can be punctured per rectum, without wounding the peritoneum (fig. 208A).

The LIGAMENTS OF THE BLADDER are ten in number, five true and five false. The *true* ligaments are two anterior passing from the back of the pubis to the prostate and neck of the bladder (fig. 128, p. 17), two lateral from the sides of the bladder to the upper sheath of the levatores ani, all four being formed of pelvic fascia, and one superior, consisting of the urachus (p. 43). The *false* ligaments are all peritoneal, viz. two posterior, two lateral, and one superior (p. 168).

FIG. 208A.—VERTICAL SECTION OF THE MALE PELVIS. (*Semi-diagrammatic.*) (*Hughes.*)



1. Symphysis pubis. 2. Pubo-prostatic ligament. 3. Prostate. 4. Anterior wall of bladder. 5. Peritoneum. 6. Vesiculæ seminales. 7. Non-peritoneal part of second stage of rectum.

Changes in the Shape of the Bladder.—The antero-inferior or pubic surface and base of the bladder are fixed to a considerable extent, and are but slightly changed in position during distension. When the bladder is empty, the peritoneal or abdominal wall descends like the roof of a tent and becomes applied to the antero-inferior surface and base, so that the cavity is flattened from above downwards and, on antero-posterior sections, is shaped like a very open V, the anterior limb of the V being much longer than the posterior, and the angle of the V placed at the outlet or meatus of the bladder. During distension, the postero-superior wall is gradually raised so that the cavity becomes ovoid in form.

INFANTILE BLADDER.—In the very young child, the bladder is placed at a considerably higher level than in the adult. The urethral orifice is, at the time of birth, on a level with the upper part of the symphysis pubis. The whole organ is then abdominal in position. The cavity of the bladder is spindle-shaped. The basal surface is not differentiated from the postero-superior surface, and the lower part of the recto-vesical pouch extends as far as the base of the prostate.

The **bladder in the female** (fig. 195, p. 167) is more spherical and broader from side to side than in the male. The base is separated by a layer of pelvic fascia from the roof of the vagina and cervix uteri. The neck terminates in the short female urethra without being surrounded by anything comparable to the prostate in the male. The ureters reach the base of the bladder by passing forwards on each side of the cervix uteri, close to the lateral fornices of the vagina.

The *female urethra* is a short canal about one inch and a quarter in length, and extends from the neck of the bladder to the *meatus urinarius*, and opens on the vestibule. It is imbedded in the anterior wall of the vagina (fig. 195, p. 167).

Coats of the Bladder.—The peritoneum only covers the posterior superior (abdominal) surface. It is firmly bound to the bladder.

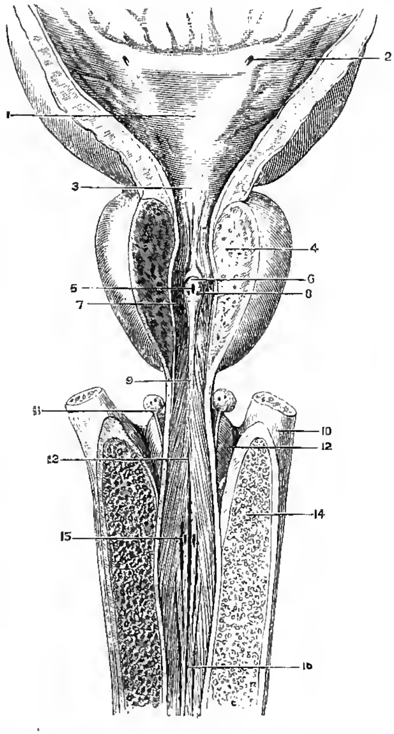
Besides the peritoneal the other coats are:

(1) Fibrous, forming the capsule of the organ, the anterior and the lateral true ligaments. It is continuous at the neck with the capsules of the prostate and vesiculæ seminales.

(2) Muscular (fig. 208). The bundles of muscular fibres are arranged in a reticulated manner. Between the retinacula, the mucous membrane is sacculated when there is obstruction to the egress of urine. The outer or more superficial fibres

are attached to the base of the prostate (in the male) and neck of the bladder, both in front and behind, and ascend towards the apex. These fibres, which are specially well marked between the ureters, are distinguished as the *detrusor urinæ.*

Fig. 209.—The trigone of the bladder and urethra laid open from the front. (*After Wilson.*)



1. Trigonum vesicæ. 2. Opening of ureter. 3. Uvula vesicæ, indicating the apex of the trigone. 4. Ventral wall of prostate laid open. 5. Opening of sinus pocularis. The orifices of the ejaculatory ducts lie one on either side of this. 6. Veru montanum. 7. Mucous membrane. 8. Prostatic sinus and openings of prostatic ducts. 9. Membranous part of the urethra. 10. Crus penis (cut). 11. Cowper's gland and commencement of its duct. 12. Upper surface of the bulb. 13. Commencement of bulbous portion of urethra. 14. Section of crus penis. 15. Entrance of duct of Cowper's gland. 16. Spongy part of the urethra.

(3) When a wide window is made on the postero-superior surface the smooth lining of mucous membrane is seen. It is bound to the muscular coat by the sub-mucous tissue. This is loose everywhere except over the trigone of the bladder, where it is firmly bound and immovable. On the rest of the bladder, the mucous membrane is thrown into folds as the bladder empties.

Interior of the Bladder. The following points are to be noted :

(1) The openings of the two ureters (fig. 209, 2). The openings are valvular slits about 1¼ inches apart. A probe should be passed into them; the intra-mural part of the ureter passes obliquely outwards and upwards, and is half an inch in length. The openings are so oblique as to act as valves, preventing, in normal conditions, regurgitation of the urine from the bladder.

(2) A transverse band of muscle passes in the bladder-wall between the openings of the ureters. It gives rise to the inter-ureteric bar (bar of Mercier) (fig. 209).

(3) The opening of the urethra. It is crescentic in shape.

(4) The *uvula vesicæ* (fig. 209, 3), an elevation on the floor of the bladder at the urethral orifice (internal meatus) (fig. 211, 5). It lies over the third lobe of the prostate and contains erectile tissue, which under certain conditions shuts off the bladder from the prostatic urethra.

(5) The *trigone* (fig. 209, 1). This is the triangular area on the base of the bladder. At its lateral angles are the openings of the ureters; the inter-ureteric bar forms its base; the apex lies at the internal meatus and contains the uvula vesicæ. The mucous membrane is bound firmly to the trigone. It rests on the second stage of the rectum. The *external trigone* corresponds to it on the outer wall of the bladder (see fig. 208).

Termination of the Vas Deferens.—The vas deferens is to be followed into the fibrous capsular tissue, which surrounds its termination and vesiculæ seminales. The tissue is firmly connected with the base of the prostate. The prostatic plexus of veins and capsule are to be removed.

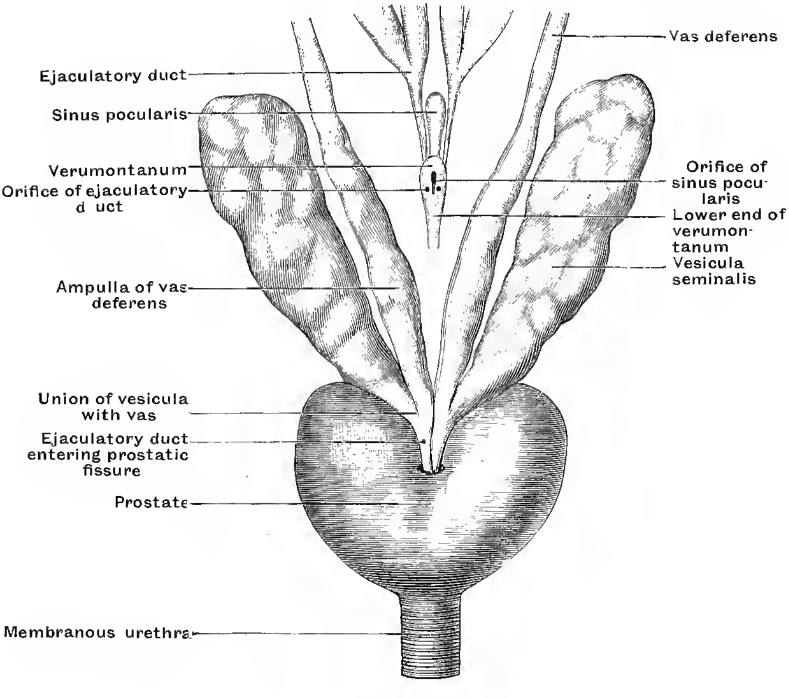
The *sacculated* terminal part of the vas deferens ends at the base of the prostate (fig. 210). There each vas joins with the duct of the vesiculæ seminales, the common ejaculatory ducts being thus formed. The lumen of this part of the vas is sacculated and contains a mucoid-like substance; in life it contains semen.

Vesiculæ Seminales (fig. 210).—They rest in a fibrous capsule between the bladder and rectum (fig. 128, p. 17). They can be felt, per rectum, lying in front of the second stage. When cleaned and separated, each is seen to be made up of a tube, about 6 or 8 inches long, with irregular lateral diverticula opening into it. They are secretory glands, which throw a mucoid material into the common ejaculatory duct, where it mixes with the semen. Their walls are fibro-muscular. Their lumen is irregular; here and there it is of considerable width.

Common Ejaculatory Ducts.—By these two narrow ducts, which are about $\frac{3}{4}$ inch long, the secretion of the testes and vesiculæ seminales is thrown into the floor of the prostatic urethra. The openings of the ducts are narrow. They open at the lateral margins of the sinus pocularis (figs. 209 and 210). The common ejaculatory ducts traverse the prostate. Between them and the base of the bladder lies the third lobe of the prostate (fig. 189, p. 155, and fig. 211).

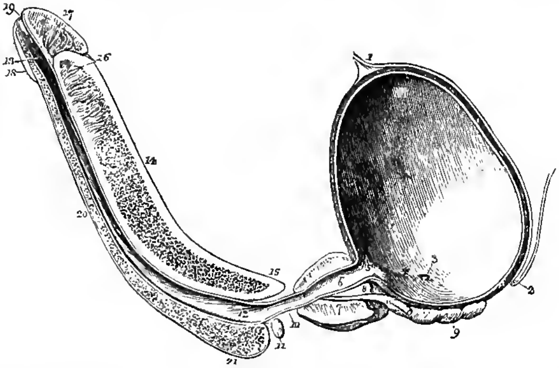
The Prostate (see figs. 208A, 209, 210, and 211).—It is chestnut-shaped and surrounds the urethra for 1¼ inches (fig. 210). On its *base* the neck of the bladder rests and the common ejaculatory ducts enter. Its *apex* rests on the posterior layer of the triangular ligament, with which its capsule is continuous (fig. 189, p. 155). Its *posterior surface* lies on the termination of the second stage of the rectum and can be examined per anum (Plate XLI, p. 158). Its *pubic* (*anterior*) *surface* is directed towards the symphysis pubis and is bound by the pubo-prostatic ligament. Its *lateral surfaces* lie on the pubic parts of the two levatores ani, which form a bed for it. Its capsule is continuous with the upper sheath of these muscles.

FIG. 210.—VASA DEFERENTIA AND VESICULÆ SEMINALES. (*After Sappey.*)


Vas deferens
Ejaculatory duct
Sinus pocularis
Verumontanum
Orifice of ejaculatory duct
Orifice of sinus pocularis
Lower end of verumontanum
Vesicula seminalis
Ampulla of vas deferens
Union of vesicula with vas
Ejaculatory duct entering prostatic fissure
Prostate
Membranous urethra

Lobes (see figs. 210 and 211).—It is made up of three lobes, two *lateral* and a *third* or median lobe. The lateral lobes unite over the urethra (pubic commissure) and behind it (rectal commissure). The third lobe is marked off from them by the passage of the common ejaculatory ducts. This is best seen on section (fig. 189, p. 155). The third lobe is seen to lie behind the urethra and below the uvula vesicæ, and above the common ejaculatory ducts (fig. 211, 8). It is not unfrequently absent; in men over 55 it is liable to become enlarged and project into the bladder behind the internal meatus. It then gives rise to obstruction of the outflow of urine, with hypertrophy of the bladder-walls. The prostate is a sexual gland; it degenerates on castration.

FIG. 211.—SECTION OF THE BLADDER, PROSTATE, PENIS, AND URETHRA. (*Wilson.*)



1. Urachus. 2. Recto-vesical fold of peritoneum. 3. Opening of the right ureter. 4. A slight ridge, formed by the muscle of the ureter, and extending from the termination of the ureter to the commencement of the urethra. This ridge forms the lateral boundary of the trigonum vesicæ. 5. Commencement of the urethra; the elevation of mucous membrane immediately below the figure is the uvula vesicæ. The constriction of the bladder at this point is the neck of the bladder. 6. Prostatic portion of the urethra. 7. Prostate gland; the difference of thickness of the gland above and below the urethra is shown. 8. Isthmus, or third lobe of the prostate, immediately beneath which the ejaculatory duct is seen passing. 9. Right vesicula seminalis; the vas deferens is seen to be cut short off, close to its junction with the ejaculatory duct. 10. Membranous portion of the urethra. 11. Cowper's gland of the right side, with its duct. 12. Bulbous portion of the urethra; throughout the whole length of the urethra of the corpus spongiosum numerous lacunæ are seen. 13. Fossa navicularis. 14. Corpus cavernosum, cut somewhat obliquely to the right side, near its lower part. 15. Right crus penis. 16. Near the upper part of the corpus cavernosum the section has fallen a little to the left of the middle line; a portion of the septum pectiniforme is consequently seen. This figure also indicates the thickness of the fibrous investment of the corpus cavernosum, and its abrupt termination at the base of (17) the glans penis. 18. Lower segment of the glans. 19. Meatus urinarius. 20. Corpus spongiosum. 21. Bulb of the corpus spongiosum.

STRUCTURE.—It is contained in a strong fibrous capsule and made up of a fibro-muscular stroma containing convoluted tubular prostatic glands. These open mainly in the prostatic sinus.

Prostatic Urethra.—The pubic commissure is to be divided and the urethra laid open (fig. 209). The following structures are to be noted :—

(1) *Veru montanum* (*crista urethræ, caput gallinaginis*), a ridge of mucous membrane and submucous tissue which continues the uvula vesicæ forwards on the floor of the prostatic urethra.

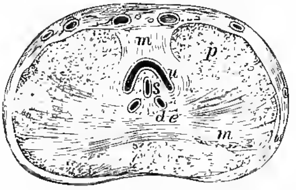
(2) The *sinus pocularis* or uterus masculinus, a blind pit at the anterior end of the veru montanum (figs. 209 and 212). It represents the vagina and uterus of the female. It projects backwards into the prostate between the ejaculatory ducts. It varies in size and depth, but as a rule is only big enough to admit a fine probe for about one quarter of an inch. Its mouth is contracted.

(3) The *openings of the common ejaculatory ducts* on the lateral margins of the sinus pocularis (fig. 210).

(4) The *sinus prostaticus*, a depression at each side of the veru montanum. Into this sinus open most of the prostatic glands.

The prostatic stage of the urethra is 1¼ inches long; it is wide and dilatable. The mucous membrane is surrounded by a layer of circular muscular fibres, continuous above with vesical fibres, and below with the constrictor urethræ. On transverse section, the elevation of the veru montanum gives the lumen a crescentic shape (fig. 212). The urethra is widest in the middle of the prostatic stage.

Fig. 212.—Transverse section of the prostate. (*Allen Thomson*).



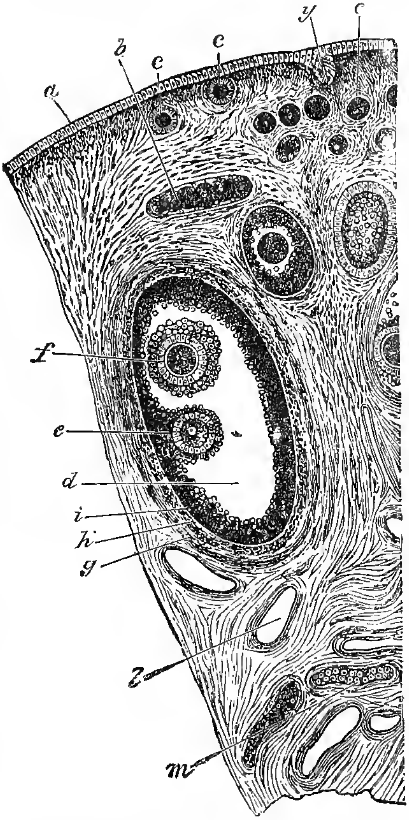
u. Urethra. *s*. Sinus pocularis. *d*, *e*. Common ejaculatory ducts. *p*. Glandular substance. *m*, *m*. Muscular tissue. The capsule, containing the prostatic plexus, is also shown.

The *membranous stage* of the urethra, ¾ inch in length, situated between the two layers of the triangular ligament, the bulbous and penile parts, 5½ inches in length, have been already examined (fig. 212).

The Ovaries.—The ovaries are two slightly elongated bodies compressed from side to side, and about 1¼ inches in length (fig. 214). Each ovary lies behind the outer part of the broad ligament, in close relation to the pelvic wall, and normally rests in a depression—the *fossa ovarii*—between the external and internal iliac arteries (fig. 198).

Position.—The ovary varies considerably in its position, especially after the occurrence of pregnancy or displacement of the uterus. In the virgin state it lies in the ovarian triangle on the lateral pelvic wall. One end or pole is directed backwards towards the brim of the pelvis (pelvic pole), one is directed forwards and inwards towards the uterus (uterine pole) (fig. 214). The *posterior or free border* lies in front of the internal iliac artery. Its *anterior* border is fixed to the posterior layer of the broad ligament by the mesovarium (fig. 197, p. 170). At the fixed border or hilum, the ovarian vessels, nerves, and lymphatics enter or leave. The pelvic pole of the ovary is connected by a fold of peritoneum, the ovario-pelvic ligament, with the peritoneum of the iliac fossa. Through this fold the ovarian arteries and nerves reach the broad ligament and ovary; the ovarian veins and lymphatics pass upwards in it (fig. 197, p. 170). To the pelvic pole, too, is attached the ovarian fimbria of the Fallopian tube. This keeps the trumpet-shaped end of the tube attached to the ovary (fig. 196). The uterine pole of the ovary is fixed to the upper angle of the uterus by the *round ligament* of the ovary. The ligament is attached at the uterine cornu behind and below the Fallopian tube.

FIG. 213.—SECTION OF OVARY. (*Waldeyer.*)



a. Germ epithelium. *b.* Ovarian tube, or string of primordial ova. *c, c. c.* Early vesicles. *d.* A more mature Graafian follicle or vesicle. *e.* Ovum and discus proligerus. *f.* A second ovum in the same vesicle. *g.* Tunica fibrosa of vesicle. *h.* Inner coat of the vesicle. *i.* Epithelial lining (tunica granulosa). *l.* Blood-vessel, cut across. *m.* Section of tubes of parovarium. *y.* Involuted portion of germ epithelium of surface.

Frequently, as the result of inflammation, the ovary is found buried in a mass of adhesions on the lateral pelvic wall. The outer end of the Fallopian tube may be found included in the mass.

The surface of the ovary is covered by germinal epithelium, which is continuous at the hilum with the peritoneal endothelium of the mesovarium and broad ligament (fig. 213). In the child the surface is smooth, but after puberty it becomes roughened by the cicatrices formed at the points where successive ova escaped.

The ovary is supplied by the ovarian plexus of nerves from the aortic, which descends on the ovarian artery (fig. 175). The ovary can be obscurely palpated through the vagina, and also through the belly wall by pressing outwards two inches above the spine of the pubis.

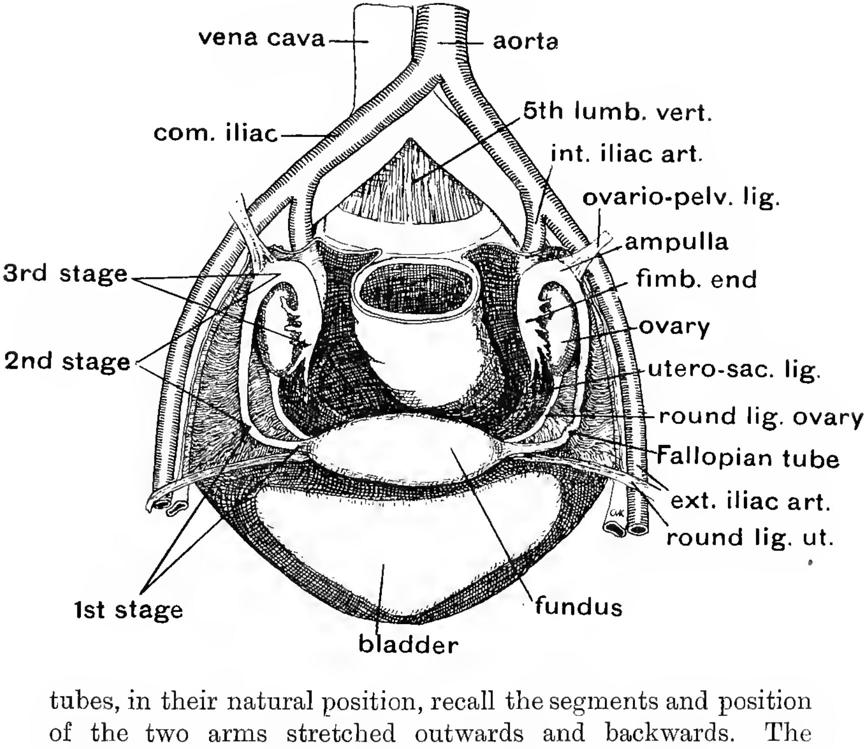
COURSE OF THE OVA.—In the natural position, the fimbriæ of the Fallopian tube clutch and cover the convex or free surface of the ovary (fig. 214). When an ovum is shed, which in the sexual period of life occurs every month at least, it can scarcely escape the ciliated fimbriæ. The ciliæ work towards the ostium abdominale of the tube, situated at the bases of the fimbriæ, and carry the ovum through it into the tube itself (fig. 196). The ciliæ of the tube carry it on towards the uterus. In the tube it is fertilised by a spermatozoon or escapes free. The fertilised egg passes on to the uterus.

Fallopian Tubes.—The *Fallopian tubes*, or *oviducts*, extend one on each side from the region of the ovary to the lateral angle of the uterus, lying in the upper free margin of the broad ligament (fig. 196, p. 169). They transmit the ova, discharged on the surface of the ovary, to the cavity of the uterus. Occasionally the fertilised ovum is arrested in the tube and develops there. Ultimately it bursts the tube and drops within the layers of the broad ligament or into Douglas's pouch. Each tube is between four and five inches long, and opens at its outer extremity by means of a small opening, the *ostium abdominale*, into the peritoneal cavity. *Internally*, the duct pierces the uterine wall to open in the lateral horn of its cavity by the *ostium uterinum*.

MESO-SALPINX (figs. 196 and 197, p. 170).—The upper part of the broad ligament forms a mesentery for the Fallopian tube (fig. 197). To this triangular fold of the peritoneum the term meso-salpinx is given. To its outer free end is attached the ovarian fimbria (fig. 196). It becomes continuous below with the remainder of the broad ligament at the ovary and its round ligament behind, and at the round ligament of the uterus in front (fig. 197). Between the layers of the meso-salpinx lie branches of the ovarian vessels (fig. 204); also remnants of the Wolffian body, a series of tubules which may become dilated into large cysts (fig. 215).

Position.—The Fallopian tube is at first transverse in its direction and slightly arched, but at the lateral wall of the pelvis it turns backwards round the outer surface and posterior border of the ovary (fig. 214). If the uterus be regarded as a decapitated trunk, the position and direction of the Fallopian tubes, in their natural position, recall the segments and position of the two arms stretched outwards and backwards. The *isthmus* or brachium stretches horizontally outwards; the brachial is the narrowest stage and about one inch in length. The *ampulla* or ante-brachium passes obliquely backwards on the lateral wall of the pelvis; the ante-brachial stage is dilated and contains numerous longitudinal folds of mucous membrane. The *infundibulum*, fimbriated extremity, or manus, hangs downwards and clutches the ovary. The outer or fimbriated extremity

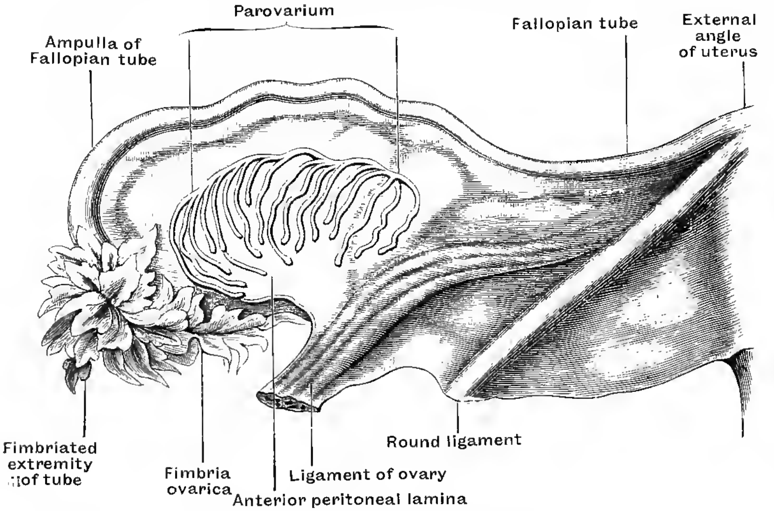
Fig. 214.—Diagram showing the position and stages of the Fallopian tube.



of the tube is widely expanded and divides into a number of fringe-like processes or *fimbriæ*, at the bases of which is the *ostium abdominale*. One of the fringes is longer than the rest and extends to the ovary (*fimbria ovarica*). This presents a well-marked groove extending from the ovary to the ostium abdominale. Similar but less marked grooves are seen on the other fimbriæ (fig. 196). Frequently a small pedunculated cyst, or hydatid, is attached to one of the fimbriæ.

Removal of the Uterus.—The uterus, broad ligaments, ovaries, and upper half of the vagina are now to be removed. The lower part of the vagina is left *in situ*, imbedded in the pelvic floor. In removal of the uterus the following structures are cut: the peritoneum binding it to the rectum; the broad ligament, at its attachment to the lateral pelvic wall; the ovarian vessels, nerves, and lymphatics, the uterine vessels and nerves (fig. 197, p. 170). The ureter has been already removed. So has the bladder and its connections with the uterus and vagina. The posterior aspect of the vagina is then freed from the rectum; it is divided as it passes between the levatores ani muscles. The connective tissue in the broad ligament and the vaginal fibrous sheath are continuous with the rectal sheath and recto-vesical fascia or upper layer of the sheath of the levator ani.

Fig. 215.—The broad ligament and its contents, seen from the front. (*After Sappey.*)



The **Contents of the Broad Ligament** must be reviewed (figs. 196, 197 and 215). They are :

(1) The Fallopian tube in its free margin. The part of the broad ligament which forms the mesentery of the tube is the meso-salpinx.

(2) The round ligament of the ovary. The ovary is attached to the posterior layer of the broad ligament.

(3) Remnants of the Wolffian body (fig. 215). These are contained between the layers of the meso-salpinx and lie between the Fallopian tube and the ovary. They consist of a main duct or tube joined by minor tubules, arranged at right angles to it. Those above the ovary form the *epoöphoron, parovarium* or organ of *Rosenmüller*; those situated between the ovary and uterus, the *paroöphoron.*

(4) The round ligament of the uterus (fig. 215).

(5) The ovarian artery, vein, lymphatics, and nerves. The artery anastomoses with the uterine artery at the side of the uterus.

(6) The uterine artery, vein, lymphatics, and nerves.

(7) Much connective tissue continuous with the sheath of the levator ani.

(8) The ureter passes obliquely forwards in the basal part of the ligament (fig. 197).

THE UTERUS

The Uterus.—Fixation. The uterus is often displaced ; it may prolapse through the vagina and appear in the vulva. It is important, therefore, to note the structures that retain it in position. They need be only named ; they have already been examined.

(1) The *levatores ani and their upper sheath*, the recto-vesical fascia. The vagina and cervix of the uterus rest on the levator muscles ; the muscular and visceral sheaths are continuous.

(2) The *peritoneum* forming the broad ligaments, utero-sacral folds, recto-uterine and utero-vesical reflections, and the connective tissue within these folds.

(3) The *round ligaments* of the uterus.

(4) The *pressure of surrounding viscera.* Through the

viscera the muscular abdominal parietes keep up a constant pressure on the uterus.

The vagina and cervix are fixed ; the body of the uterus, on the other hand, is freely movable.

Parts seen in a Vertical Section of the Uterus.—Before commencing the actual dissection of the uterus and vagina, the student should consult such a section of the pelvis as is shown in fig. 195, p. 167. In it he should note the following points :

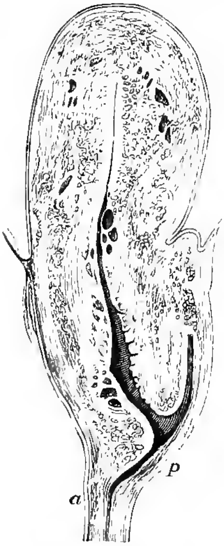
(1) That the *axes of the vaginal and uterine cavities* meet at an angle. The angle varies in extent owing to the mobility of the body of the uterus. The axis of the vagina, if continued backwards, strikes the sacrum near its middle vertebra ; normally the axis of the uterus passes downwards towards a point between the anus and the tip of the coccyx. The uterus appears to open on the roof of the vagina.

(2) The *os externum* of the uterus, through which the cavity of the cervix uteri communicates with the vagina (fig. 216).

(3) The *os internum*, through which the uterine cavity communicates with the cervical.

(4) The body of the uterus is normally bent forwards on the cervix at the os internum. In fig. 195 the uterus is retroflexed.

FIG. 216. — SAGITTAL SECTION OF UTERUS AND UPPER PART OF VAGINA. (*After Henle.*)



a, Anterior, p, Posterior vaginal wall.

(5) The short anterior lip, the prominent posterior lip of the os externum (fig. 216). The deep posterior fornix of the vagina lies behind the posterior lip ; the shallow anterior fornix in front of the anterior lip.

(6) That any instrument thrust through the posterior fornix will pass into the pouch of Douglas.

(7) The position of the vagina between the second stage of the rectum behind and the base of the bladder and urethra in front (fig. 195, p. 167).

BLOOD SUPPLY OF THE UTERUS (fig. 204, p. 181).—The uterus is supplied by the two ovarian and two uterine arteries. The uterine and ovarian artery of each side form an anastomotic chain on the lateral margin of the uterus. From the chain, vessels perforate the muscular coat and ramify on both the anterior and posterior walls. The veins accompany the arteries. In pregnancy the vessels enlarge, especially the ovarian.

NERVE SUPPLY.—From the pelvic plexus and nervi erigentes (p. 184).

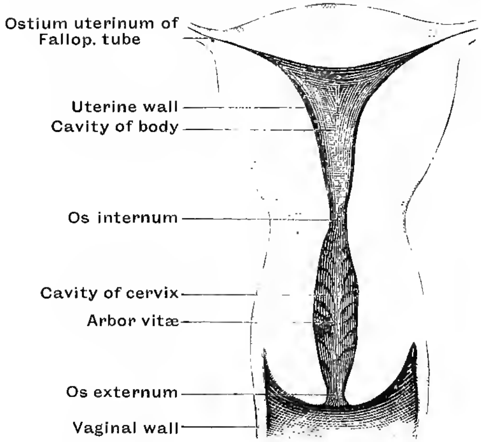
The *lymphatics* from the fundus pass with the ovarian lymphatics to the lumbar glands. The lymphatics from the body of the uterus, the cervix and upper part of the vagina pass to the internal iliac glands (fig. 204).

The **Uterus** is now to be examined. It is seen to be a hollow viscus, pyriform in shape, with thick muscular walls, its thicker end being uppermost and continuous laterally with the Fallopian tubes, its thinner lower extremity being embraced by the upper end of the vagina (fig. 217). In the normal unimpregnated state the uterus is about three inches long and, at its broadest and thickest part, is two inches wide and one inch in thickness. The uterus is divided into a *body* and *cervix*; externally this division is but slightly marked (excepting in the young child), but is distinctly seen internally (figs. 216 and 217).

RELATIONS.—The body is covered in front and behind by the peritoneum of the utero-vesical and recto-uterine pouches respectively (fig. 195, p. 167). These separate the surfaces of the uterus from the bladder and rectum. *Laterally* the body is in relation to the broad ligament, with the Fallopian tube, round ligament and ligament of the ovary at its upper part. *Superiorly*, the rounded *fundus* is in relation to coils of the small intestine. The *ligament of the ovary* extends outwards and backwards to the ovary. The *round ligament* of the uterus extends under a fold of peritoneum to the internal abdominal ring, where it enters the inguinal canal to terminate in front of the pubis in the labium majus (fig. 214). It is accompanied by a peritoneal tube in the young subject, forming the canal of Nuck. This usually becomes obliterated.

The **Cervix Uteri** (figs. 216 and 217) is about an inch in length, and projects downwards into the upper part of the vagina, to the anterior wall or roof of which it is firmly fixed. One third of the cervix is clearly intra-vaginal, one third supra-vaginal; the middle third is intra-vaginal behind and supra-vaginal in front (fig. 216). The *intra-vaginal* portion of the cervix is covered by the vaginal mucous membrane, and presents an orifice, the *os uteri externum*, which is directed towards the posterior wall of the vagina. This part of the cervix is frequently the seat of cancer and consequently of operation. The *supra-vaginal* portion of the cervix is covered behind by the peritoneum of the pouch of Douglas; the anterior surface is devoid of peritoneum and rests against the base of the bladder below the limits of the utero-vesical pouch. *Laterally* the ureters pass obliquely downwards and forwards, at a distance of half an inch from the cervix (fig. 197).

Fig. 217.—Frontal section of a virgin uterus. (*After Sappey.*)



Coats of the Uterus (figs. 216 and 217).—(1) Serous or peritoneal. (2) Muscular. The non-striated muscle fibres form bands arranged in all directions. The muscular coat forms by far the greater part of the uterine wall. It increases rapidly during pregnancy. (3) Submucous. (4) Mucous.

Interior of the Uterus.—The cavity of the body of the uterus should be opened by a transverse or coronal section from cervix to fundus (fig. 217). It is triangular in shape, and compressed from before backwards into a mere cleft (fig. 216). At its upper and lateral angles it opens into the Fallopian tubes, and inferiorly communicates with the cavity of the cervix through the os uteri internum.

The *cavity of the cervix* is fusiform on coronal section. It communicates with the cavity of the uterus above, while inferiorly it opens through the *os uteri externum* into the upper part of the vagina.

Mucous Membrane.—In the body of the uterus the mucous membrane is smooth. It contains tubular glands. The epithelium is columnar and ciliated. In the cervix the mucous membrane is thrown into longitudinal and oblique folds, giving rise to the appearance known as the *arbor vitæ* (fig. 217). The longitudinal folds are two in number, one in front and one behind, and from these the numerous oblique folds pass upwards and outwards on the cervical wall. Between these folds some distended mucous follicles are occasionally seen. These are the so-called *ovula Nabothi*. The cervix takes no part in menstruation nor in the formation of the placenta. It is larger than the body of the uterus at birth.

The Vagina.—The vagina extends downwards and forwards from the cervix uteri to the vulval cleft (fig. 195, p. 167). Its cavity is compressed above from before backwards, so that its anterior and posterior walls are in contact. Below it is H-shaped in section, the anterior and posterior walls being still in contact. *Superiorly* it embraces the lower part of the cervix uteri, which is implanted on its roof or anterior wall (fig. 216). Around the cervix uteri, the vagina encloses a circular recess which is deepest posteriorly (posterior fornix). *Anteriorly* the base of the bladder rests against the vagina, and the urethra descends to the vestibule in close contact with, and imbedded in, the vaginal wall. *Posteriorly* the vagina is mostly in contact with the second part of the rectum, but at its upper end it comes into relation with the deep part of the pouch of Douglas, and its lower part is separated from the anal canal by a wedge-shaped mass, the *perineal body* (fig. 195).

Laterally it is supported by the pubic fibres of the levatores ani, which descend on the sides of the vaginal wall to the central point of the perineum, and at its lower end it is encircled by the sphincter vaginæ. The ureter, as already seen, lies close to the upper part of the lateral wall and roof of the vagina. The vagina passes between the levatores ani and through the triangular ligament, and opens in the vulval cleft (fig. 200, p. 174).

Coats.—The *mucous membrane* of the vagina presents a number of transverse folds or rugæ, which are best marked near the lower end. There they unite together in front and behind to form the *anterior* and *posterior* longitudinal columns of the vagina. The mucous membrane is covered by stratified epithelium. The *submucous* coat is lax and vascular, containing a plexus of veins. Outside the submucous layer is a *fibro-muscular* coat. That in turn is covered with the *fibrous sheath.* The vagina is richly supplied by sensory nerves from the pelvic plexus. Its arteries come from the uterine, inferior vesical, and internal pudic. Its veins join the uterine and are connected with the vesical and hæmorrhoidal.

THE RECTUM

The Rectum.—Only the rectum now remains in the pelvis. It is to be removed. It is easily detached from the sacrum; loose connective tissue unites the second stage to the 'rectal bed' of the pelvic floor. The rectal bed is formed by the last two vertebræ of the sacrum, the coccyx, the pyriformis, the coccygeus, posterior or coccygeal part of the levatores ani, and recto-vesical fascia covering the upper surface of the pelvic floor.

The Rectum in Vertical Section.—A section of the pelvis, showing the rectum in position, should be examined (fig. 208A, p. 188).

(1) Note the direction of the narrow *anal canal,* the terminal part of the rectum. In the standing position it is directed downwards and backwards. In front of it is the triangular perineal body, separating it in the male from the bulb and base of the triangular ligament; behind it is the ano-coccygeal body.

(2) The second stage of the rectum follows the curve of the lower half of the sacrum and of the coccyx. It impinges against the posterior surface of the prostate, and turns backwards to join the anal canal about an inch and a half beyond the tip of the coccyx.

(3) The reflection of the peritoneum from the rectum to the bladder or uterus, at the bottom of the recto-vesical pouch in the male, recto-uterine (pouch of Douglas) in the female. The edge of the reflection is 3½ inches distant from the anus.

Stages and Relationships.—The rectum commences at the left sacro-iliac joint and terminates at the anus. It has been already exposed in the sacral and coccygeal regions (Dissection II). At first it inclines obliquely downwards and inwards towards the right side of the pelvis, reaching the middle line opposite the third piece of the sacrum. The attachment of the meso-rectum runs in an oblique line from the left sacro-iliac articulation to the middle of the second or third sacral vertebræ. The rectum is concave forwards, corresponding to the curvature of the sacrum and coccyx. One and a half inches beyond the tip of the coccyx it is inclined downwards and backwards.

For convenience of description the rectum is divided into three stages or parts.

The **first part** passes obliquely inwards to the third piece of the sacrum, and is covered completely by peritoneum and connected to the posterior pelvic wall by the meso-rectum, between the layers of which the superior hæmorrhoidal vessels descend. *In front* of it are some coils of the small intestine.

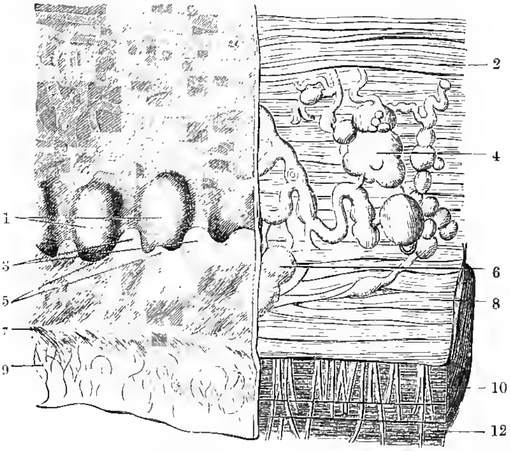
The **second part** extends from the third piece of the sacrum to 1½ inches beyond the tip of the coccyx. It is covered partially in front and laterally by peritoneum (fig. 208A, p. 188). The *anterior surface* is covered above by the peritoneum of the lower part of the recto-vesical pouch; beyond this it is separated from the base of the bladder and terminations of the ureters by the vesiculæ seminales, vasa deferentia and their capsular tissue. Near its termination it comes into relation with the posterior surface of the prostate in the male, beneath which it forms a *cul-de-sac* (fig. 128, p. 17), and with the vagina in the female. *Posteriorly* it is devoid of peritoneum, and rests directly on the sacrum, coccyx and ano-coccygeal body.

The **third part** of the rectum, or **anal canal** of Symington, is rather more than an inch in length. It is imbedded in the pelvic floor or diaphragm and extends from the second stage to the anus. It is a potential canal, patent only during defæcation. It lies between the two ischio-rectal fossæ, and is surrounded almost throughout by the internal sphincter muscle and near its termination by the external sphincter (fig. 218). Laterally it is supported by the levatores ani muscles. The membranous urethra lies in front of its upper part (fig. 189, p. 155). The perineal body separates it from the vagina in the female, the membranous and bulbous parts of the urethra in the male.

Structure of the Rectum.—The rectum, when compared with the other parts of the large intestine, presents peculiarities as regards its serous, muscular, and mucous coats. The incomplete nature of the *serous coat* has been referred to (p. 166).

The *muscular coat* at the commencement of the rectum is similar to that of the colon, the longitudinal coat having three well-marked bands or tæniæ between which the rectal wall is sacculated. These bands soon become spread out and form a uniform muscular layer on the remainder of the rectum. The circular coat is specially thickened round the anal canal, and forms the internal sphincter (fig. 218).

Fig. 218.—Inner surface of the anal canal. (*After Luschka.*)



1. Lacunæ between the columns of Morgagni. 2. Circular muscular fibres. 3. Demarcation between anal and rectal portions of the mucous membrane. 4, 6. Varicose hæmorrhoidal veins. 5. Anal portion of mucous membrane with columns of Morgagni. 7. White line of Hilton, at junction of internal and external sphincters. 8. Internal sphincter. 9. Cutaneous zone above anal aperture. 10. Tendinous fibres of longitudinal muscular coat. 12. External sphincter.

The *mucous membrane* is also somewhat modified. In the first and second parts the transverse and oblique folds found throughout the colon are better marked, and form, in the second part, two or three prominent folds known as the *valves of Houston*, the most prominent being on the right antero-lateral wall, near the base of the prostate. These may catch the point of a rectal bougie. In the *anal canal* the mucous membrane is thrown into longitudinal folds, the *columns of Morgagni*, which disappear on distension of the gut. At their upper and lower ends the columns of Morgagni are connected by fine transverse valvular folds of the mucous membrane (fig. 218). When the anal canal is closed the valves meet together and completely occlude the passage, preventing the escape of fluid fæces. They may be torn in defæcation, and thus give rise to anal fissures.

Within the margin of the anus, near the lower ends of the columns of Morgagni, the stratified epithelium of the skin meets the columnar epithelium of the rectum (fig. 218, 7). A white line (Hilton's) may be detected in life; it marks the line of separation between the internal and external sphincters (fig. 218).

Blood-vessels of the Rectum.—The *superior hæmorrhoidal* artery passes down in the meso-rectum and divides into two branches, which descend one on each side of the rectum, external to the muscular coat. About 5 or 6 inches above the anus these divide into several branches which pierce the muscular coat and descend beneath the mucous membrane to opposite the upper margin of the internal sphincter. These, having subdivided and joined with branches of the *middle hæmorrhoidal* arteries from the internal iliac, form a vascular network in the sub-mucous tissue around the gut. From this network several straight vessels pass downwards along the anal canal in relation to the columns of Morgagni, and terminate by joining twigs of the *inferior hæmorrhoidal* branches of the internal pudic artery in another vascular circular network close to the anus.

The hæmorrhoidal *veins* correspond to the arteries and form a plexus on the rectum. The hæmorrhoidal plexus terminates partly in the portal system by means of the superior hæmorrhoidal vein, while the middle and inferior hæmorrhoidal veins enter the caval system. The middle hæmorrhoidal terminates in the internal iliac vein, and the inferior hæmorrhoidal in the pudic vein.

The *nerves* of the rectum are derived from (1) the hypogastric plexus; (2) pelvic plexus and 4th sacral; (3) the inferior hæmorrhoidal of the internal pudic.

The *lymphatics* pass from the lower part to the internal iliac group of glands; from the upper, to the sacral glands in the meso-rectum.

The attachments of the levator ani, obturator internus, and their sheaths should be again reviewed (p. 174).

The pelvis is then divided by vertical incisions so as to separate the sacrum with part of the ilium from the rest of the pelvis. The sections are made at the sacro-sciatic foramina.

Structures on the Pelvic Surface of the Sacrum.—The structures remaining on the anterior surface of the sacrum after the removal of the rectum are now to be examined (fig. 203, p. 179, and fig. 206, p. 184).

They are: (1) The sacral plexus. (2) The sacral ganglia of the sympathetic chain. (3) The origin of the pyriformis muscle. (4) The lateral and middle sacral vessels. (5) Lymphatic glands in the attachment of the meso-rectum. (6) Anterior sacral and sacro-coccygeal ligaments.

With the removal of the lower part of the sacrum and coccyx the anterior sacro-coccygeal ligaments and the lowest sacral ganglia and coccygeal body or gland were cut away (see p. 12).

SACRAL PLEXUS

Sacral Plexus (fig. 206).—The sacral plexus is formed on each side by the lumbo-sacral cord, derived from the anterior divisions of the 5th lumbar and part of the 4th, the anterior divisions of the 1st, 2nd, 3rd, and part of the 4th sacral nerves. The extent to which the 4th lumbar and 4th sacral nerves enter into the formation of the plexus varies widely. The 4th sacral may take no part whatsoever. The upper three sacral nerves emerge on each side at the anterior sacral foramina and unite with the lumbo-sacral cord and part of the 4th sacral nerve to form a terminal nerve-trunk—the GREAT SCIATIC NERVE- and a minor terminal, the PUDIC NERVE (fig. 206, p. 184).

Branches.—From the sacral plexus arise the following nerves:—

A. Terminal.
  1. The Great Sciatic, from the lumbo-sacral cord, 1st, 2nd, 3rd, and occasionally the 4th sacral.
  2. The Pudic, from the 2nd, 3rd, and 4th sacral.

B. Collateral Branches.
  1. Muscular branches to the pyriformis (1st and 2nd sacral); to the quadratus femoris (lumbo-sacral cord and

1st sacral); to the obturator internus (5th lumbar and 1st sacral).

2. Superior Gluteal, from the lumbo-sacral cord and 1st sacral.
3. Inferior Gluteal, from the lumbo-sacral cord, 1st and 2nd sacral.
4. Small Sciatic, from the 1st, 2nd, and 3rd sacral.
5. Visceral branches which join the pelvic plexus from the 2nd, 3rd, and 4th sacral.

Relations.—The sacral plexus lies on the inner aspect of the pyriformis and outside the pelvic fascia, which here forms the inner sheath of that muscle. The internal iliac vessels and their branches lie on the inner aspect of the plexus, separated from it by the pelvic fascia. The posterior aspect of the second stage of the rectum is in contact with the lower part of both plexuses. The first stage of the rectum and termination of the ileum lie in front of them above.

Besides the part which joins the sacral plexus, the 4th sacral nerve gives off visceral, muscular and cutaneous branches (see page 16). The 5th sacral and coccygeal nerves have been already traced (p. 12).

Sacral Ganglia (fig. 206, p. 184).—The sympathetic cord is continued from the lumbar region down on each side of the sacrum. A ganglion lies internal to each of the four upper sacral nerves, and a fifth median ganglion (ganglion impar) rests between the fifth pair. The rami communicantes between the 2nd, 3rd, and 4th sacral nerves and ganglia are composed of both white and grey fibres. The white rami contain visceral efferent fibres on their way to the pelvic plexus and pelvic viscera (sensory, motor, vaso-motor).

The Origin of the Pyriformis and its intra-pelvic portion can be seen. The sheath on the pelvic aspect of the muscle is thin and separates the sacral plexus from the internal iliac vessels. The rectum lies on its origin.

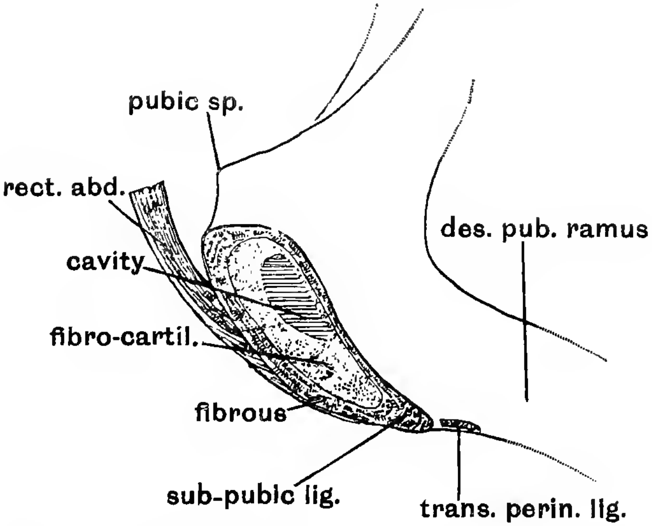
The *sacral vessels* have been already described (see p. 180, fig. 203).

There now remain for examination two important joints, the symphysis pubis and sacro-iliac articulation.

Symphysis Pubis.—The symphysis pubis is sometimes divided subcutaneously by the surgeon. When it is divided in life it gapes, the body of the pubis of one side separating from the other for about ¾ of an inch. The capacity of the pelvis is thereby increased.

The adjacent surfaces of the pubic bones are covered by cartilage (fig. 219); between the cartilaginous surfaces, and binding them firmly together, is a disc of fibro-cartilage containing a cavity or fissure. Behind, above, in front and below, surrounding the core of fibro-cartilage, strong transverse superficial fibres unite the bones together. Tendinous fibres of the rectus abdominis and external oblique mingle with the anterior transverse fibres of the symphysis.

FIG. 219.—SECTION OF THE SYMPHYSIS PUBIS.



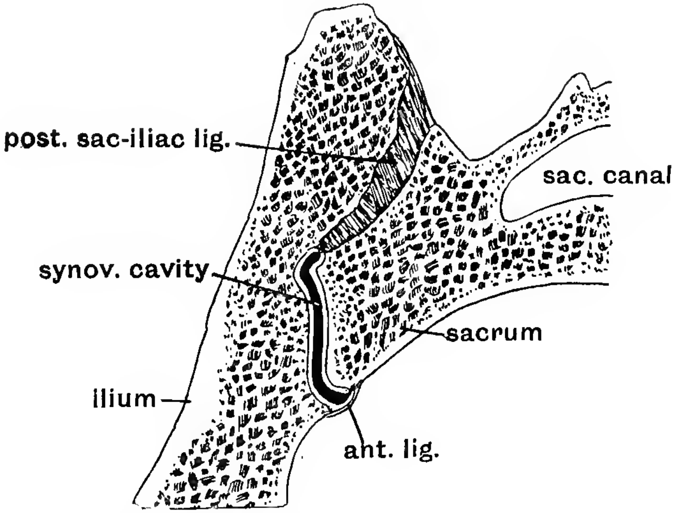
Below the symphysis and continuous with the inferior transverse fibres, is the strong subpubic ligament (fig. 219). Below it and above the transverse perineal ligament, the dorsal vein of the clitoris or penis passes backwards (fig. 190, p. 160). The bladder and prostate lie behind the symphysis, loose tissue intervening.

Sacro-iliac Articulation (fig. 220).—The section of the pelvis, made to gain access to the cavity, opens this articulation. The ilium should be disarticulated and the following points noted:

(1) That the ear-shaped articular surface of the sacrum and

the corresponding surface of the ilium are coated thickly with cartilage, and that they are separated by an indistinctly marked synovial cavity. Further, that while the lips of the iliac surface overlap the sacral surface in front above, the reverse is the case below: the sacral surface overlaps the iliac. It must be remembered, in explanation of this, that the sacrum is nearly horizontal in the standing position and that the weight of the trunk tends to weigh the base of the sacrum into the pelvis and tilt its tip upwards behind. The mutual imbrication of the two bones prevents this.

FIG. 220.—SECTION OF THE SACRO-ILIAC ARTICULATION.



(2) Behind the articular area there is a wide, rough surface filled with thick, strong ligamentous bands. These make up the *posterior sacro-iliac ligament.* Besides the posterior transverse fibres, there is a superficial band of oblique fibres, passing from the posterior inferior spine to the side of the sacrum. This band is the *posterior oblique sacro-iliac ligament.*

(3) The short transverse anterior and superior sacro-iliac ligaments cross in front of and above the articular surface from sacrum to ilium (fig. 194).

(4) The great and small sacro-sciatic ligaments also serveto strengthen the joint between the sacrum and os innominatum.

DISSECTION OF THE THORAX

DISSECTION I

THE WALLS AND BOUNDARIES OF THE THORAX

For some reason, probably because its dissection takes much less time than the other parts, the medical student has come to regard the thorax as one of the less important parts of the body. If the dissector entertains such an idea he must dismiss it, for he will find that clinically he has to deal with this part of the body more frequently than any other. It contains the heart and lungs. He must start with the definite idea of mastering: *first*, the mechanism of the heart; *second*, the mechanism of respiration; *third*, the exact relations of the heart and lungs to the surface of the thorax.

He must master these and remember them, otherwise he cannot be a successful physician. He should observe, however, that the removal of the upper limbs, the clavicles, scapulæ, pectoral and scapular muscles and the abdominal walls, has destroyed many landmarks and quite altered the appearance of the *clinical* thorax.

The **thoracic walls** are already exposed and are now to be examined. They present the following parts:

(1) Spinal wall.
(2) Sternal wall.
(3) Costal wall.
(4) Diaphragmatic wall or floor.
(5) Cervical wall or apex.

(1) **Spinal.**—The bodies of the twelve dorsal vertebræ and the intervertebral discs between them project within the thorax, and form a narrow spinal wall or column. This is best seen in transverse section (fig. 222).

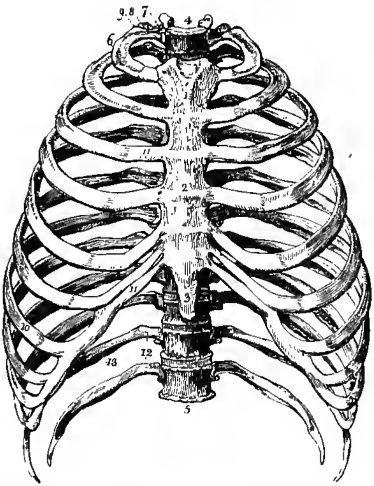
(2) **Sternal.**—The posterior surface of the sternum forms a narrow wall in front. It is very much shorter than the

posterior wall. Two dorsal vertebræ lie above the level of its upper border, and three lie below its lower end. Hence the thorax is cut away in front like a morning coat both above and below.

(3) **Costal.**—The costal wall is made up of the twelve ribs and their cartilages. The upper seven extend from the spinal to the sternal wall (fig. 221). The eighth, also, especially on the right side, may occasionally reach the sternum. Below the level of the sternal ribs the thorax is cut away in front; the cartilages of the eighth, ninth, and tenth pairs end on each other and form the subcostal margin. The *subcostal* or *infra-sternal* triangle is bounded laterally by the subcostal margins. The 11th and 12th pairs end free in the abdominal wall.

The costal wall enters into the posterior, lateral, and anterior aspects of the thorax. The dorsal segments of the ribs—from their heads to beyond their angles—are bent so as to form deep recesses on each side of the vertebral column. This is occupied by the convexity of the costal surface of the lung (fig. 222).

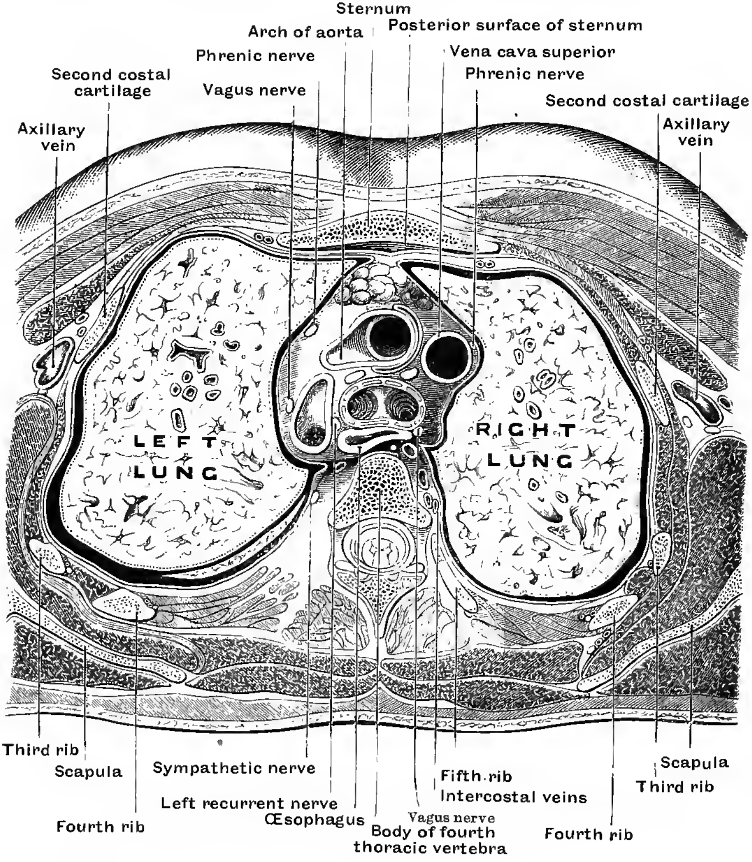
Fig. 221.—Anterior view of the thorax. (*Wilson.*)



1. Manubrium. 2. Body or gladiolus. 3. Ensiform cartilage. 4. First dorsal vertebra. 5. Last dorsal vertebra. 6. First rib. 7. Its head. 8. Its neck, resting against the transverse process of the first dorsal vertebra. 9. Its tubercle. 10. Seventh or last true rib. 11. Costal cartilages of the true ribs. 12. The last two false ribs or floating ribs. 13. The groove along the lower border of the rib.

Muscles attached to the Costal Wall of the Thorax.—Between the ribs the intercostal muscles are attached and fill up the *intercostal spaces.* To the inner surfaces of the lower six cartilages are attached the diaphragm and the transversalis; to their lower borders, the internal oblique. The rectus abdominis arises from the costal cartilages of the three lower sternal ribs; the external oblique covers the anterior and lateral aspects of the eight lower ribs and rises from them; the pectoral muscles cover the costal and sternal walls in front down to the level of the sixth pair of cartilages. The area of the thoracic wall covered by the pectoral muscles may be called for convenience the *pectoral area* of the thorax. The nipple is situated on this area, just below the level of the fourth pair of ribs.

FIG. 222.—SUPERIOR VIEW OF A SECTION OF THE THORAX, PASSING THROUGH THE STERNUM IMMEDIATELY BELOW THE FIRST COSTO-STERNAL ARTICULATION, THROUGH THE TRACHEA AT ITS DIVISION, AND THROUGH THE BODY OF THE FOURTH THORACIC VERTEBRA. (*Braune.*)

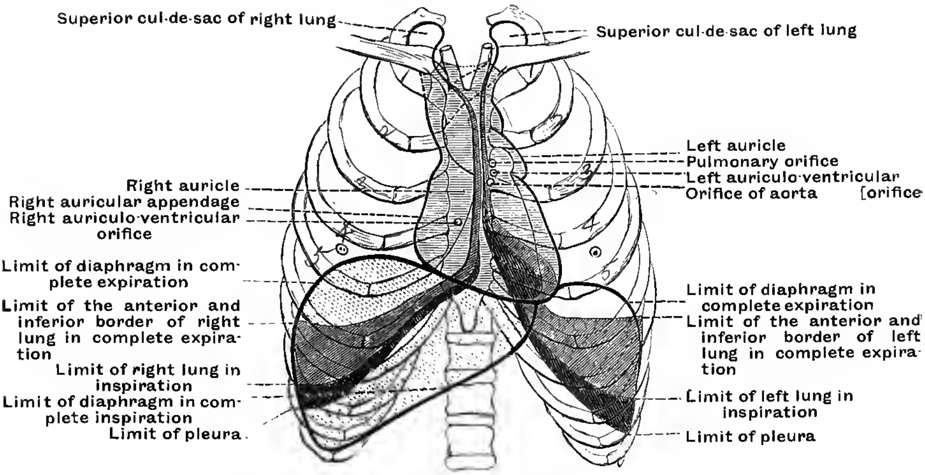


The scapula and its muscles cover the costal wall behind and at the side. The scapula rests on the second to the seventh ribs, both inclusive. Between the anterior and posterior folds of the axilla a part of the costal wall appears on the surface (*axillary area*). It is covered here by the serratus magnus, which arises from the upper eight ribs. On the dorsal aspect of the costal wall, the muscular columns of the erector spinæ are inserted.

These muscles have been enumerated here, not only because they help to clothe the chest-wall, but because every muscle with a costal attachment may act as a muscle of respiration.

(4) **Diaphragmatic Wall.**—The diaphragm forms the floor or diaphragmatic wall of the thorax. It serves as the dome-like floor of the thorax and concave roof of the abdomen (see fig. 186, p. 147). The upper level of the right dome—for the right dome rises a little higher than the left—lies opposite the seventh dorsal vertebra, above the upper border of the fifth rib, in the nipple line, during expiration (fig. 223). From the highest point the diaphragm descends *backwards* rapidly to the level of the twelfth dorsal vertebra, where it is attached to the last rib, first lumbar transverse process, and bodies of the twelfth dorsal and upper lumbar vertebræ (fig. 187, p. 148). That is to say, there is a difference of five vertebræ in the level of the highest and lowest parts of the thoracic floor. It will be apparent that the posterior portion of the diaphragm is nearly vertical in position, and might well be described as entering into the formation of the posterior wall of the abdomen and anterior of the thorax. From the highest point of

FIG. 223.—DIAGRAM TO SHOW THE UPPER LEVEL OF THE DIAPHRAGM, AND THE POSITION OF THE HEART AND LUNGS. (*Bellamy.*)


Superior cul-de-sac of right lung
Superior cul-de-sac of left lung
Left auricle
Pulmonary orifice
Left auriculo-ventricular orifice
Orifice of aorta
Right auricle
Right auricular appendage
Right auriculo-ventricular orifice
Limit of diaphragm in complete expiration
Limit of the anterior and inferior border of right lung in complete expiration
Limit of right lung in inspiration
Limit of diaphragm in complete inspiration
Limit of pleura
Limit of diaphragm in complete expiration
Limit of the anterior and inferior border of left lung in complete expiration
Limit of left lung in inspiration
Limit of pleura

the diaphragm, the floor of the thorax slopes forwards to the level of the upper border of the seventh costal cartilage and base of the ensiform process, a descent of two or more intercostal spaces (fig. 223).

The diaphragm is the chief muscle of respiration; its dissection and examination is the work of the dissectors of the thorax. Its formation, attachments, foramina and the structures which pierce it on their way to or from the abdomen are described at p. 145. That description must be read and the diaphragm examined now as far as its abdominal aspect is concerned.

(5) **The Cervical Wall.**—The cervical wall, sometimes described as the *upper aperture* of the thorax, is enclosed on each side by a dome-like expansion of fibrous tissue (Sibson's fascia), continuous on its upper surface with the cervical fascia and structures of the neck. The fascia, which covers the apex of the lung on each side, is lined by the apical pleura (fig. 237, p. 240), and may be termed the *apical fibrous dome.* The fibrous dome on each side is attached to the inner border of the first rib from spinal to sternal end. Between the apical fibrous domes, and bounded behind by the body of the first dorsal vertebra and in front by the upper margin of the manubrium, is the **superior mediastinal passage** through which structures pass from the neck to the mediastinum or from the mediastinum to the neck (fig. 224). These structures are: (1) The Trachea—respiratory passage. (2) The Œsophagus—food passage. (3) Arterial trunks conveying blood to the head and neck and upper extremities (innominate, left carotid and left subclavian branches of the aorta). (4) Venous trunks conveying the blood of the same trunks back to the heart (right and left innominate veins). (5) Nerves—the two pneumogastrics, two phrenics. (6) Lymph channel—the thoracic duct.

Sibson's fascia and the superior mediastinal passage are perforated on each side by a number of minor structures. These are:

(1) The sterno-thyroid and sterno-hyoid muscles, attached to the posterior aspect of the manubrium, from which they act on the larynx and hyoid bone.

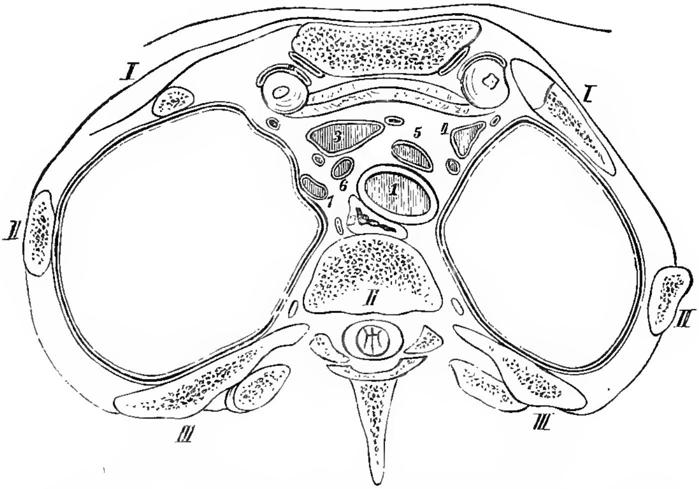
(2) The internal mammary artery, a branch of the subclavian, which passes behind the first costal cartilage and is distributed to the chest-wall.

(3) The superior intercostal artery, also a branch of the subclavian, enters in front of the neck of the first rib.

(4) Internal to it, the sympathetic gangliated chain passes from the thorax to the neck.

The *position of the cervical wall* or cervico-thoracic boundary on the surface of the body is a matter of importance. Behind, the boundary is situated at the level of the neck of the first rib and first dorsal vertebra; in front, it lies at the upper border of the manubrium and inner margin of the first rib, and points at the level of the third dorsal vertebra. The cervical wall therefore slopes rapidly forwards and downwards. The upper border of the sternal third of the clavicle is nearly on a level with the posterior attachment of the cervical wall (fig. 223) Crossing over the apical dome are—from before backwards—the subclavian vein, subclavian artery, and lowest trunk of the brachial plexus. The apex of the lung lies under the apical dome behind the sternal third of the clavicle, and subclavian vessels.

Fig. 224.—A section through the upper border of the manubrium sterni and second dorsal vertebra, to show the structures in the superior mediastinal passage. (*Braune.*)

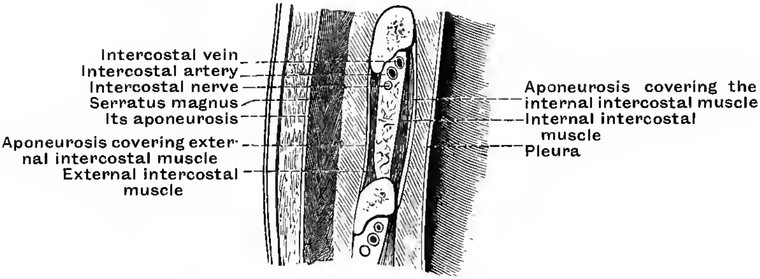


1. Trachea. 2. Œsophagus. 3. Left innominate vein. 4. Right innominate vein. 5. Innominate artery. 6. Left common carotid artery. 7. Left subclavian artery. At each side the apical parts of the lungs are shown in section. The roman numerals indicate the ribs and vertebra.

The following muscles are attached to the first rib, and by raising it can alter the level of the cervical wall of the thorax: (1) Scalenus medius; (2) Scalenus anticus; (3) Subclavius.

Structures in an Intercostal Space.—In order to see the relationship of the structures which form the costal wall a section of it should be made. The section should include an inch of each of the sixth, seventh, and eighth ribs in front of their angles. The ribs should be divided by a key-hole saw, and the structures in the intercostal spaces by a sharp knife. A window is thus made in the parietal pleura which lines the thoracic walls, the lung collapses as air is admitted, and a pleural cavity is formed. When the cut surface of the wall is examined the following structures are seen (fig. 225):

Fig. 225.—Section of the sixth left intercostal space, at the junction of the anterior and posterior thirds. (*Tillaux.*)


Intercostal vein
Intercostal artery
Intercostal nerve
Serratus magnus
Its aponeurosis
Aponeurosis covering external intercostal muscle
External intercostal muscle
Aponeurosis covering the internal intercostal muscle
Internal intercostal muscle
Pleura

(1) The ribs, showing a rounded border above, a sharp outer border below, bounding the subcostal groove. The ribs are covered with periosteum, which is easily detached.

(2) The external intercostal muscle, the fibres descending forwards and downwards from the sharp edge of the upper to the rounded border of the lower rib. The muscle has an outer (external intercostal membrane or aponeurosis) and inner sheath.

(3) The internal intercostal muscle, descending obliquely downwards and backwards. It is attached to the inner border of the subcostal groove above and the upper rounded border below. Its outer sheath is continuous with the inner sheath of the external muscle, the combined sheaths being known as the middle intercostal membrane.

(4) A layer of sub-pleural tissue covering the inner sheath of the internal muscle and the periosteum on the inner aspects

of the ribs. The outer part of this layer blends with the internal intercostal aponeurosis (fig. 225).

(5) The *parietal pleura*, with its outer rough surface bound down by the sub-pleural tissue; its inner smooth surface in life lies in contact with the visceral pleura covering the surface of the lung.

It will thus be noted that the parietal and visceral layers of the pleura are in contact (fig. 222) until the chest-wall is opened, or until fluid collects between them as in pleurisy. The *pleural space*—between the two layers—is merely a potential cavity. The cavity is formed at the expense of the lung.

(6) In the fibrous tissue between the external and internal intercostal muscles are seen the following vessels and nerve (fig. 225): (*a*) the intercostal vein in the subcostal groove; (*b*) the intercostal artery below it; (*c*) the nerve below the artery. In the lower part of the space on the convex border of the rib may be seen the collateral branch of the intercostal artery; the lower branch exists only in the anterior half of the intercostal spaces (fig. 231).

Costal Wall in the Region of the Apex of the Heart.—In life the pulsation of the apical part of the heart is most distinctly felt in the fifth intercostal space of the left side, about three inches from the side of the sternum. Here the fifth space is bounded by costal cartilages. The arrangement of structures between the costal cartilages is rather different from that between the ribs proper. The student is now to examine and dissect the structures which lie over the apex of the heart in the fifth intercostal space (fig. 226). These are:

(1) The skin and superficial fascia already removed.

(2) The origins of the pectoralis major and rectus abdominis (fig. 226).

(3) The external intercostal aponeurosis. Between the costal cartilages the external intercostal muscle is fibrous and forms this structure.

(4) The internal intercostal muscle.

(5) The intercostal vessels and nerves (fig. 226). Between the cartilages these perforate and lie deep to the internal intercostal muscles.

(6) Fasciculi of the triangularis sterni (fig. 226).

(7) The sub-pleural tissue (fig. 225).

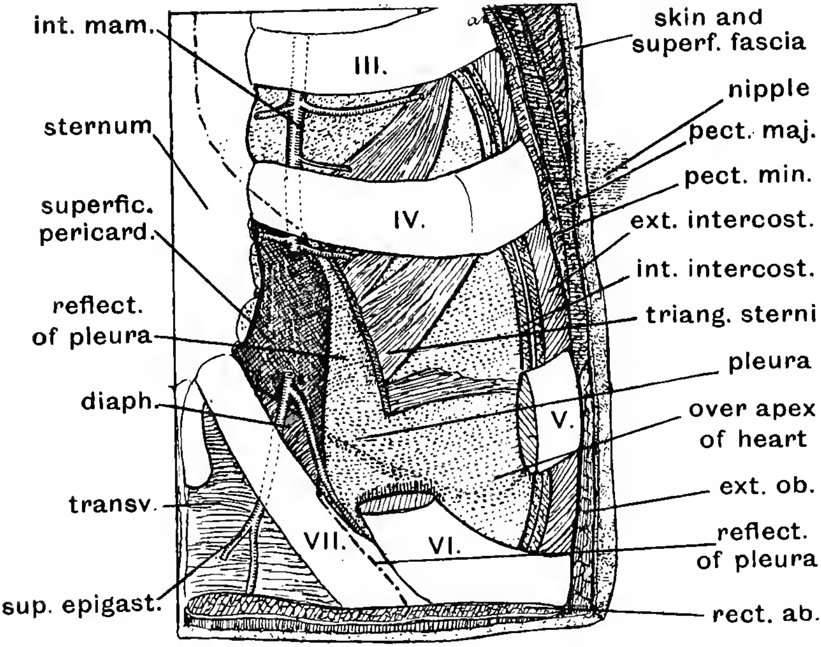
(8) The parietal pleura (fig. 226). In the fifth space and

the one above it, the parietal pleura usually does not reach the sternum, but is reflected to the pericardium, an inch or an inch and a half from it. This reflection is seen.

To give more room, two inches of the fifth and sixth costal cartilages should be cut away (fig. 226).

(9) Through a window made in the parietal pleura, the mediastinal pleura (see p. 242 and fig. 238) is seen reflected backwards on the pericardium. Between the reflection of the pleura and margin of the sternum the pericardium is exposed.

Fig. 226.—The relationships of the pericardium and pleura to the thoracic wall in the apical region. (*After Frohse.*)



(10) The pericardial sac is seen partly exposed and partly beneath the mediastinal pleura. In life the anterior edge of the lung fills the space between the parietal and mediastinal pleuræ, and thus partly covers the heart.

(11) When a window is made in the exposed part of the pericardium, the apical region of the heart is seen. The part of the heart thus exposed is the right margin and apical region of the right ventricle. The inner surface of the fibrous

pericardium is seen to be lined by a smooth layer, the parietal *serous* pericardium. On it the surface of the heart rubs. It is through these layers of tissue now dissected that the physician listens when he auscultates the heart in the region of the apex beat.

DISSECTION.—The intercostal muscles in an upper, middle, and lower intercostal space are now to be examined.

Intercostal Muscles.—These form two layers of oblique fibres, the external and internal intercostal muscles. Neither muscle extends the whole length of an intercostal space, the external being deficient in front and the internal behind.

External Intercostals.—The fibres pass obliquely downwards and forwards from the sharp lower border of the upper rib to the upper border of the lower rib of a space; they extend from the tubercles of the ribs as far as the end of the bony portion of the costal arch. Between the costal cartilages they are replaced by a thin aponeurosis, the *anterior intercostal membrane* or aponeurosis.

Internal Intercostals.—The fibres pass obliquely upwards and forwards from the upper border of the lower rib to the ridge which forms the inner margin of the subcostal groove above. On the upper spaces they extend from the sternum as far as the angles of the ribs. Behind the angles they are replaced by a thin aponeurosis, the *posterior intercostal membrane.*

NERVE SUPPLY.—From the intercostal nerves.

ACTION.—They support and maintain the intercostal spaces, their chief function being the mechanical one of forming part of a flexible chest-wall. When they contract they diminish the intercostal spaces. The upper rib is fixed by the scalene muscles and the muscles attached to the sternum. If the first rib is fixed, the combined action of the intercostal muscles would be to elevate the other ribs towards the first, and thus act as muscles of inspiration. The student may test on himself the slight degree to which these muscles act during inspiration. He will find that the twelfth rib actually descends then. The elevation of the ribs which is felt on inspiration is due mostly to the action of the diaphragm (p. 252).

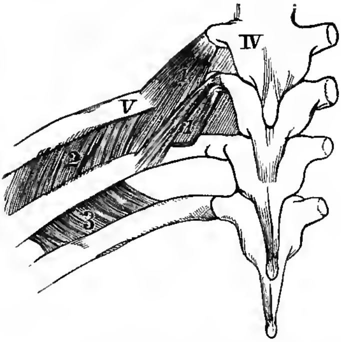
Levatores Costarum (fig. 227).—The levators of the ribs—or rather of the angles of the ribs—form a series of twelve small muscles on the dorsal aspect of the chest on each side. They are fan-shaped; their expanded ends are inserted to the upper border of the ribs between the tuberosity and angle. Their tips spring from the ends of the transverse processes of the seventh cervical to the eleventh dorsal vertebræ. Fibres may pass to two ribs. They are supplied from the intercostal nerves.

Longissimus Dorsi and Ilio-costalis.—Notice, too, how the outer and middle columns of the erector spinæ are inserted to the ribs between the tuberosities and angles (fig. 276, Part III.) They may depress the ribs, but they can also pull them backwards and expand the chest. They use the ribs as levers to act on the dorsal part of the spinal column. When the spine is most erect, the chest is most expanded.

Sternal Joints. — The *sterno-clavicular joint* is examined by the dissector of the upper extremity (see fig. 228). The upper end of the sternum serves as a rest for the clavicle.

Interchondral Joints.—The prominent angles of the fifth, sixth, and seventh costal cartilages are in contact with the upper border of the cartilages below. The points of contact are separated by synovial cavities. These may be best seen by shaving off a superficial layer of cartilage. There is a movement between these cartilages as the chest-wall rises and falls in respiration.

FIG. 227.—INTERCOSTAL MUSCLES AND LEVATORES COSTARUM. (*Wilson.*)



IV. Fourth dorsal vertebra. V. Fifth rib. 1, 1. Levatores costarum muscles, long and short. 2. External intercostal. 3. Internal intercostal.

Sterno-costal Joints.—The cartilages of the *first pair* of ribs are continuous with the manubrium sterni (fig. 228).

The *second pair* end at the lateral notches of the sterno-manubrial joint. When the superficial layer of their insertion is shaved off there is seen to be an interarticular septum with a synovial cavity above and below it (fig. 228). The joints are crossed in front and behind by anterior and posterior costo-sternal ligaments.

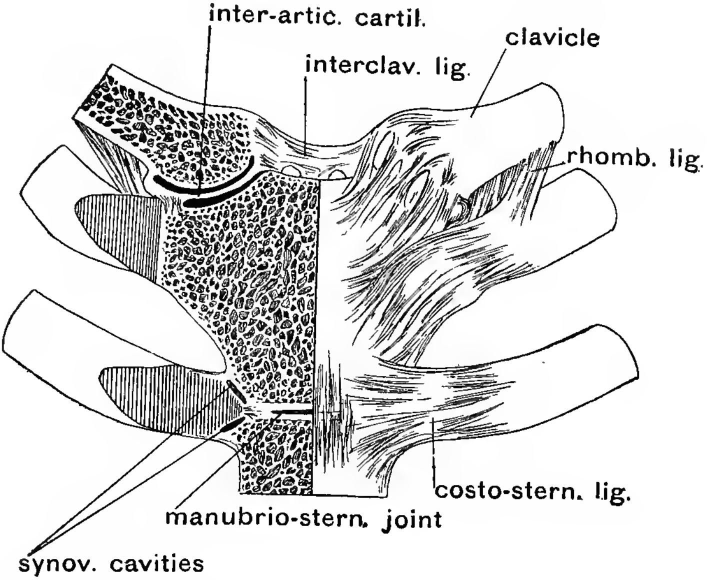
The *third and fourth pairs* are inserted in a manner similar to the second pair.

The *fifth and sixth* have only one articular facet; the synovial cavity may be absent.

The *seventh pair* and occasionally the *eighth* end in front of the terminal part of the sternum. They are bound there by ligamentous tissue.

Sterno-manubrial Joint (fig. 228).—The manubrium is bound to the sternum by a disc or layer of fibro-cartilage. Anterior and posterior fibrous ligaments cross the joint in front and behind. A synovial cavity may be present. In inspiration, the body of the sternum (meso-sternum) is bent a little inwards at this joint; the anterior sterno-manubrial angle becomes then more pronounced. This joint may be obliterated in old age.

FIG. 228.—THE STERNO-CLAVICULAR AND COSTO-STERNAL JOINTS.



Sterno-ensiform Joint.—In the young a disc of cartilage is present. About the sixtieth year the ensiform unites with the sternum. The joint is surrounded by much fibrous tissue.

Posterior Sternal Ligaments.—The posterior aspect of the sternum is covered by a layer of longitudinal ligamentous fibres, continuous with the periosteum. Above they end in the sheaths of the sterno-hyoid and sterno-thyroid muscles, and through them in the cervical fascia.

Anterior Sternal Ligaments.—Ligamentous fibres of origin of the two great pectoral muscles cross the sternum; others are arranged longitudinally. They are continuous with the tissue of the linea alba.

The sternum serves (1) as part of the thoracic wall; (2) as a fulcrum on which the sternal ribs move; (3) as a basis from which muscles act. The pectoralis major, sterno-mastoid, sterno-hyoid, sterno-thyroid, triangularis sterni, transversalis and diaphragm are attached to it (see fig. 235).

Blood Supply of the Thoracic Walls.—The vessels and nerves of the costal wall of the thorax are now to be examined. Each costal wall of the thorax is supplied by:

(1) Nine intercostal arteries, branches of the aorta (fig. 230).
(2) The internal mammary, a branch of the first stage of the subclavian (fig. 229).
(3) The superior intercostal, a branch from the second stage of the subclavian (fig. 232, 8).

The intercostal membrane and internal intercostal muscle are to be removed from the interchondral parts of the upper eight spaces. The internal mammary arteries will then be found passing down each side of the sternum, rather more than half an inch from its lateral margin (fig. 229). Anterior perforating branches come through the spaces to the pectoral muscles and skin. Two anterior intercostal branches pass outwards in each space. The internal mammary divides behind the sixth cartilage into *superior epigastric*, which pierces the diaphragm, and the *musculo-phrenic*, which passes outwards above the costal attachment of the diaphragm, supplying two branches to each space, as low as the tenth, and also twigs to the diaphragm. Behind the artery lie the pleura and triangularis sterni (fig. 226).

To Open the Thorax.—To examine the arteries and nerves with greater ease, it is better now to remove the costal wall on each side. This is done: (1) By detaching the cartilages between the first and seventh ribs from the sternum, and dividing the pleura and triangularis sterni; (2) by running the knife along the outer border of the first rib from its sternal end to its tuberosity; (3) by cutting through the lower six ribs (except the twelfth) and the pleura above the attachment of the diaphragm; the line of section will be found to correspond to the costo-chondral junctions; (4) by dividing the ribs internal to their angles by a bone forceps. By these four sections the greater part of each costal wall is removed.

To Raise the Lung.—There are two difficulties to be surmounted. It is rather uncommon to find the lung free; in dissecting-room subjects, either from tuberculosis or pleurisy, the parietal and visceral pleuræ are partly or completely adherent, and it requires considerable force to free the costal wall from the lung. Even if free, a difficulty will be found in raising the posterior convex border of the lung so as to expose the spinal wall of the thorax and the origins of the

Fig. 229.—The arteries of the thoracic and abdominal walls.

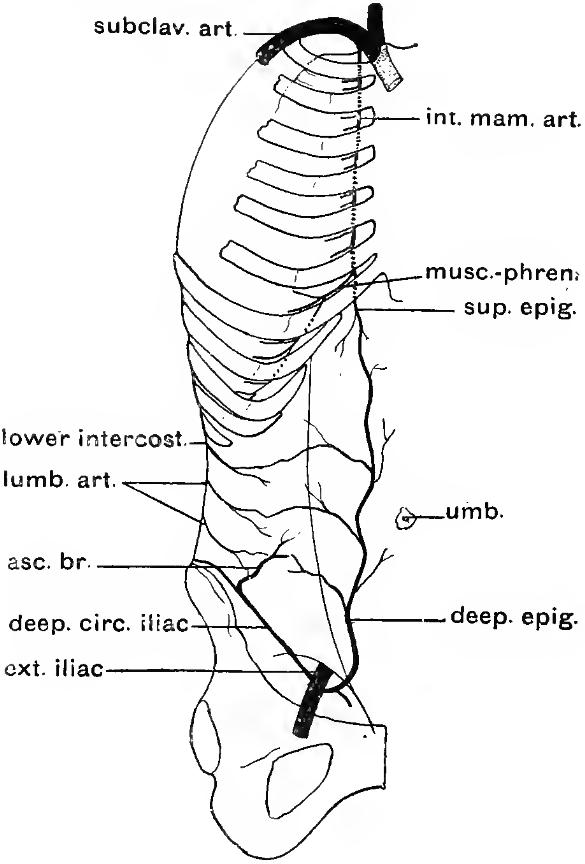
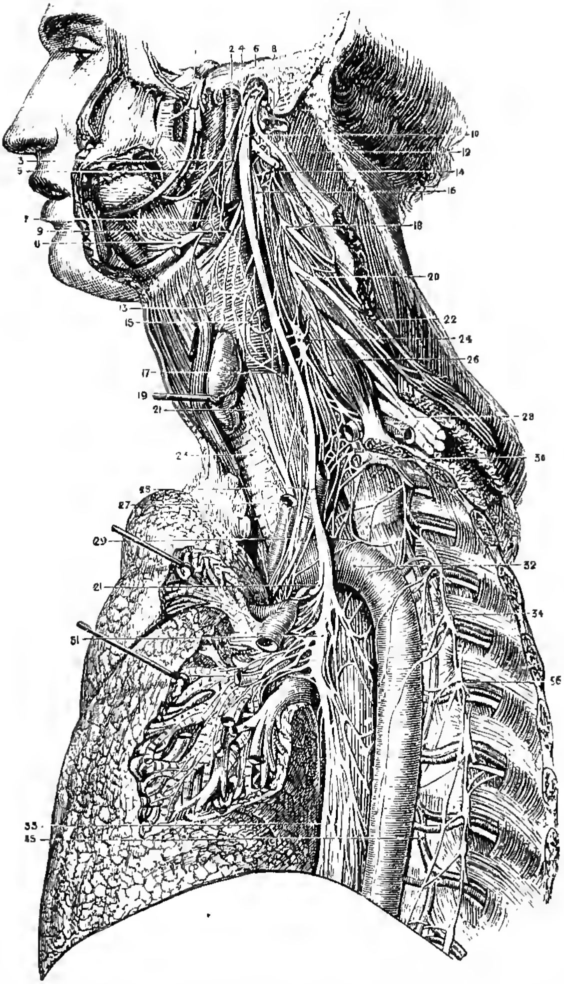


FIG. 230.—THE COURSE OF THE LEFT VAGUS AND ORIGIN OF THE INTERCOSTAL ARTERIES AND NERVES. (*Hirschfeld and Leveillé.*)



1. Gasserian ganglion. 2. Internal carotid artery. 3. Pharyngeal branch of pneumogastric. 4. Glosso-pharyngeal nerve. 5. Lingual nerve (fifth). 6. Spinal-accessory nerve. 7. Middle constrictor of pharynx. 8. Internal jugular vein (cut). 9. Superior laryngeal nerve. 10. Ganglion of trunk of pneumogastric nerve. 11. Hypoglossal nerve on hyo-glossus. 12. Ditto communicating with eighth and first cervical nerve. 13. External laryngeal nerve. 14. Second cervical nerve looping with first. 15. Pharyngeal plexus on inferior constrictor. 16. Superior cervical ganglion of sympathetic. 17. Superior cardiac nerve of pneumogastric. 18. Third cervical nerve. 19. Thyroid body. 20. Fourth cervical nerve. 21, 21. Left recurrent laryngeal nerve. 22. Spinal-accessory, communicating with cervical nerves. 23. Trachea. 24. Middle cervical ganglion of sympathetic. 25. Middle cardiac nerve of pneumogastric. 26. Phrenic nerve (cut). 27. Left common carotid artery. 28. Brachial plexus. 29. Phrenic nerve (cut). 30. First dorsal ganglion of sympathetic. 31. Posterior pulmonary plexus of pneumogastric. 32. Thoracic aorta. 33. Œsophageal plexus. 34. Vena azygos superior. 35. Vena azygos minor. 36. Gangliated cord of sympathetic.

intercostal vessels and nerves, and maintaining it in the raised position. If these two difficulties are found insurmountable, then the student must turn first to the dissection of the lung and pleura (p. 238), and afterwards return to the vessels and nerves of the costal wall when the lung has been removed.

Intercostal Vessels.—The nine lower intercostal spaces are mainly supplied by the intercostal branches of the thoracic aorta, the two upper spaces being supplied by the superior intercostal artery, a branch of the subclavian.

The *aortic intercostal arteries* (fig. 231), nine in number, arise from the posterior surface of the aorta, in the posterior mediastinum, and enter their respective spaces by passing underneath the pleura and gangliated cord of the sympathetic (fig. 230). Owing to the aorta lying to the left of the middle line, the arteries of the right side are longer than those of the left side and pass over the bodies of the vertebræ and underneath the œsophagus, vena azygos major, and thoracic duct. After each artery enters its space it lies between the pleura and ~~ex~~internal intercostal muscle, and then passes forwards between the external and internal intercostal muscles, close to the subcostal groove, having the intercostal vein above and the intercostal nerve below it (fig. 225). In front of the angle it gives off a collateral branch to the lower part of the space which, with the terminal artery, anastomoses with the two anterior intercostal branches of the internal mammary artery in each space (fig. 229).

Branches.—(*a*) A *dorsal* branch (fig. 231) passes backwards between the transverse processes, internal to the superior costo-transverse ligament. It supplies a *spinal* branch, through the intervertebral foramen, to the canal and cord. The dorsal artery passes backwards with the posterior branch of a spinal nerve, and ends in the muscles and integuments of the back (fig. 231).

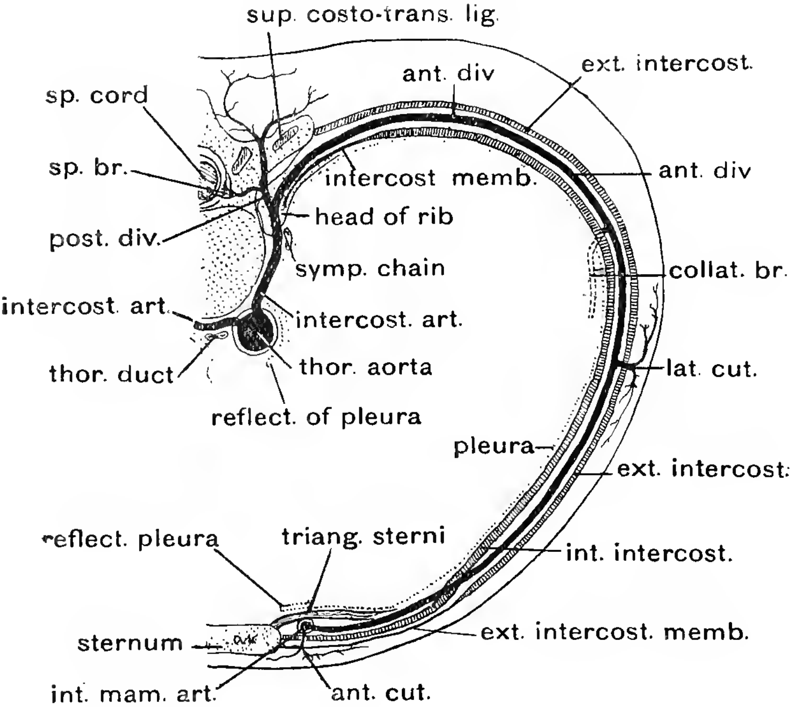
(*b*) A *collateral* branch (fig. 231) passes forwards on the upper border of the lower rib of the space. This anastomoses in the anterior part of each space with the lower anterior intercostal branch of the internal mammary artery.

(*c*) A *lateral* branch (fig. 231) accompanies the lateral cutaneous branch of the corresponding intercostal nerve ; from the upper of these, branches are supplied to the mammary gland.

(*d*) Muscular branches are supplied to the intercostal muscles.

The **Superior Intercostal Artery** supplies the upper two intercostal spaces in a manner similar to the aortic intercostals. It springs with the deep cervical from the second stage of the subclavian. It reaches the first intercostal space by passing over the neck of the first rib on the outer side of the sympathetic cord. It lies outside the pleura and over the first dorsal nerve (fig. 232, s).

Fig. 231.—The distribution of a typical intercostal artery.



The **Deep Cervical Artery,** which may be regarded as its dorsal division or branch, reaches the back of the neck by passing between the neck of the first rib and the transverse process of the seventh cervical vertebra. It then ascends between the complexus and semispinalis and anastomoses with the princeps cervicis of the occipital artery.

Internal Mammary Artery (fig. 229).—The internal mammary springs from the first stage of the subclavian artery. It at once passes down on the outer surface of the pleura, behind the subclavian vein. The phrenic nerve lies sometimes to its outer, sometimes to its inner side. It enters the thorax behind the cartilage of the first rib. Passing down about half an inch from the margin of the sternum behind the costal cartilages as far as the sixth interspace, it divides into its two terminal branches, the *superior epigastric* and *musculo-phrenic arteries*.

In the thorax it lies at first between the costal cartilages and the pleura, but beyond the second or third interspace the triangularis sterni separates it from the pleura (fig. 226). It is accompanied by *venæ comites*, which unite above to form a single vein. This opens into the innominate vein of its own side.

Branches.—(1) *Anterior intercostal*, two into each space. These anastomose with the terminal and collateral branches of each intercostal artery. Beyond the sixth interspace they are derived from the musculo-phrenic artery. They lie deep to the internal intercostal muscle at their origin, but pierce the muscle as they pass outwards (fig. 231).

(2) *Comes nervi phrenici* joins the phrenic nerve and passes to the diaphragm. It is commonly of very small size.

(3) *Sternal* to the back of the sternum.

(4) *Perforating* to the integuments and muscles of the front of the chest. Those of the third, fourth, and fifth spaces supply the mammæ.

(5) *Pericardiac* and *mediastinal*.

(6) The *superior epigastric* passes behind the seventh costal cartilage to enter the sheath of the rectus abdominis. It joins the branches of the deep epigastric and lumbar arteries (fig. 229).

(7) *Musculo-phrenic*.—It passes downwards and outwards on the upper surface of the diaphragm behind the seventh, eighth, and ninth costal cartilages, and supplies two anterior intercostal branches to each space as low as the tenth. Its terminal twig pierces the diaphragm and ends by anastomosing with the phrenic arteries. Branches are supplied to the diaphragm.

Veins of the Intercostal Spaces (fig. 232).—The venous blood is returned from the intercostal spaces by the following veins :

Right Side.

(1) Vena azygos major.
(2) Right superior intercostal vein.
(3) Intercostal vein of first space.
(4) Right internal mammary vein.

Left Side.

(1) Left inferior vena azygos, or vena azygos minor inferior.
(2) Left superior vena azygos, or vena azygos minor superior.
(3) Left superior intercostal vein.
(4) Intercostal vein of first space.
(5) Left internal mammary vein.

In the spaces the arrangement of the veins corresponds to that of the arteries. Both arteries and veins supply the rich sub-pleural vascular plexus. The terminations of the veins differ on the right and left sides.

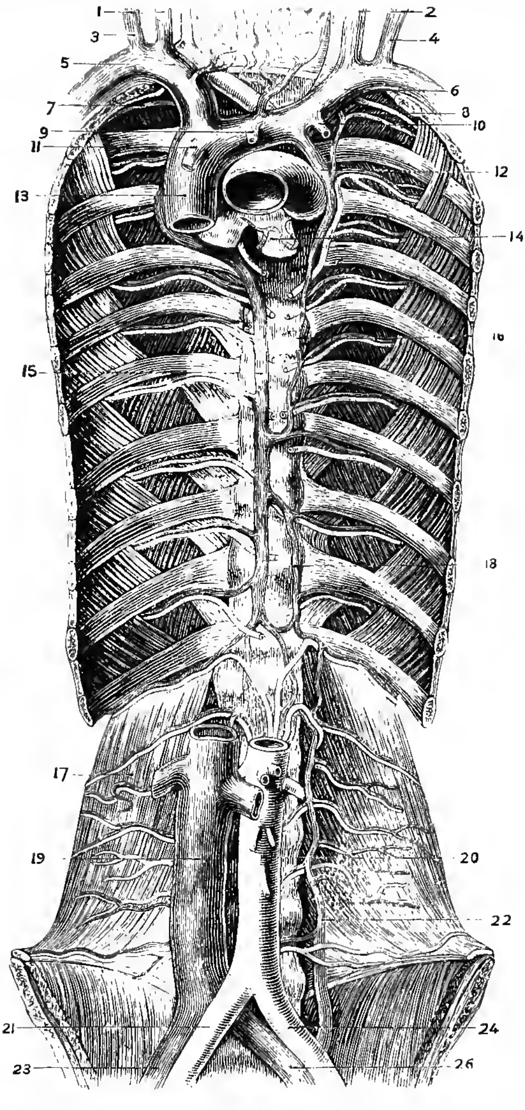
(1) The *intercostal vein of the first space* on both sides ends in the innominate vein, or a branch of the innominate.

(2) *Vena Azygos Major* (fig. 232, 15).—The intercostal veins of the lower ten spaces of the right side join the vena azygos major. The veins from the second, third, and fourth spaces unite in a common trunk before joining it (*right superior intercostal vein*). The anterior intercostals of these spaces end in the internal mammary vein. The vena azygos major begins in the abdomen by tributaries from the ascending lumbar and renal veins (fig. 232). It can be seen beneath the pleura, lying in the posterior mediastinum, but the pleura should not be disturbed now. It can be followed behind and over the root of the right lung to its junction with the superior vena cava (fig. 237). It enters the thorax with the thoracic duct by the aortic opening of the diaphragm.

(3) The *internal mammary vein* is represented by venæ comites. These unite and end in the innominate vein.

(4) The *left inferior vena azygos* commences in the abdomen in the same manner as the vein on the right side. It perforates the left crus as a very small vein and receives the veins of the lower three spaces, then crosses behind the structures of the

FIG. 232.—THE AZYGOS AND ASCENDING LUMBAR VEINS. (*Cruveilhier.*)



1. Right internal jugular vein. 2. Left internal jugular vein. 3. Right external jugular vein. 4. Left external jugular vein. 5. Right innominate vein. 6. Left innominate vein. 7. Right superior intercostal vein. 8. Left superior intercostal artery. 9. Thymic vein. 10. Left internal mammary vein. 11. Right internal mammary vein. 12. Left superior intercostal vein, joining superior hemi-azygos vein. 13. Vena cava superior, receiving the vena azygos major. 14. Left bronchus. 15. Vena azygos major. 16. Vena azygos superior. 17. Quadratus lumborum. 18. Inferior hemi-azygos vein. 19. Vena cava inferior. 20. Abdominal aorta. 21. Right common iliac artery. 22. Ascending lumbar vein. 23. Right common iliac vein. 24. Left common iliac artery. 26. Left common iliac vein.

posterior mediastinum, in which it lies, and joins the vena azygos major (fig. 232).

(5) The *left superior vena azygos* receives the intercostal veins of the fifth, sixth, seventh, and eighth spaces. It crosses the posterior mediastinum a little above the last and terminates in the vena azygos major.

(6) The *left superior intercostal* vein is of embryological interest. It corresponds to the terminal part of the vena azygos major and part of the superior vena cava (see fig. 247, p. 266). It receives the intercostal veins of the second, third and fourth spaces of the left side, passes over the arch of the aorta beneath the pleura, and terminates in the left innominate vein (fig. 232, 12). A branch can frequently be traced from it to the pericardium. It pierces the pericardium and passes into the vestigial fold of Marshall and ends in the coronary sinus of the heart. This small branch represents the left superior vena cava. Cases occur in which it replaces the right superior vena cava (fig. 247). In the early fœtus both right and left superior venæ cavæ exist.

Intercostal Nerves.—The costal wall is supplied by twelve pairs of intercostal nerves, each pair lying below the corresponding pair of ribs. Each intercostal nerve represents the anterior division of a dorsal spinal nerve (fig. 233).

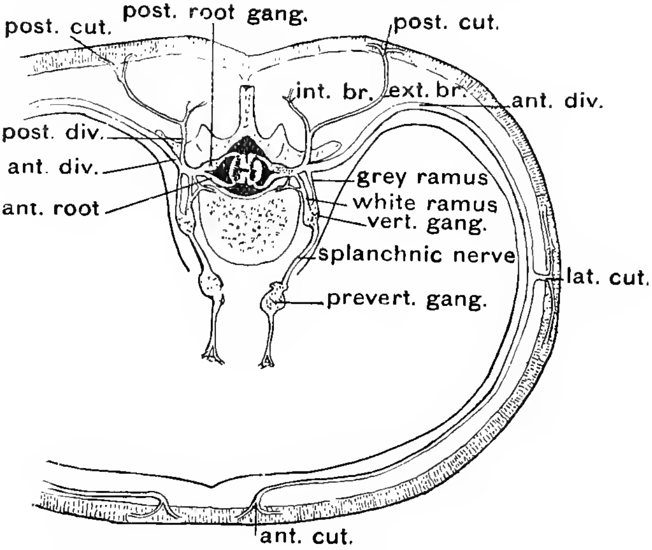
ORIGIN AND COURSE.—The dorsal nerves are formed in the intervertebral foramina by the union of the anterior and posterior roots, and emerge from each foramen above the head of the rib which forms the lower boundary of the spaces to which the nerve belongs. Hence the nerves lie below the intercostal arteries (fig. 230).

As each nerve emerges from the foramen it divides into an *anterior* and *posterior division* (fig. 233). The anterior division forms the intercostal nerve. It passes forwards first in the sub-pleural tissue, then between the internal intercostal membrane and the external intercostal muscle, and beyond the angles, between the internal and external intercostal muscles. Between the cartilages of the ribs it passes deep to the internal intercostal. The anterior terminal branches of the upper six nerves perforate at the side of the sternum and form the *anterior cutaneous* branches to the skin of the anterior part of the chest (fig. 233). The anterior cutaneous branches of the upper two nerves are very slight.

The lower six nerves (seventh to twelfth pairs) pass beneath the costal cartilages, enter the belly-wall, and end by perforating the rectus muscle and its sheath. They end as the *anterior cutaneous branches* of the abdomen (fig. 132, p. 24).

The intercostal nerves supply the intercostal muscles; the lower six also supply the muscles of the belly-wall. They also supply the triangularis sterni and serratus posticus superior and inferior. All the muscles supplied by the intercostal nerves may act as muscles of respiration.

Fig. 233.—The distribution of a typical dorsal nerve.



Lateral Cutaneous Branches.—Each intercostal nerve, a little distance in front of the angles of the ribs, gives off a large lateral cutaneous branch which perforates the external intercostal muscle and is distributed to the skin on the side of the body (fig. 233). As they emerge at the origin of the external oblique muscle of the abdomen, each lateral cutaneous nerve divides into anterior and posterior branches (fig. 119, p. 4). The lateral cutaneous branches of the first, second, third, and twelfth nerves differ from the typical nerves just described. The lateral cutaneous branch of the first nerve is said to be absent; it would, perhaps, be more correct to say that it is of great size, crosses the neck of the first rib, joins the eighth cervical nerve to form the lower trunk of the brachial plexus, and is thus distributed to the arm. Part of the second intercostal nerve may join it. The lateral cutaneous branch of the *second nerve* perforates the costal wall in the axillary area (inner wall of axilla) and passes without dividing to the skin of the arm as the intercosto-humeral nerve. The *third lateral cutaneous nerve,* as a rule, sends twigs to the skin of the arm. It divides into anterior and posterior branches, like the typical nerves; it is the posterior branch which reaches the arm and posterior wall of the axilla. The lateral cutaneous nerve of the *twelfth dorsal nerve* forms the iliac branch. It does not divide into anterior and posterior branches. It corresponds to the intercosto-humeral of the upper extremity.

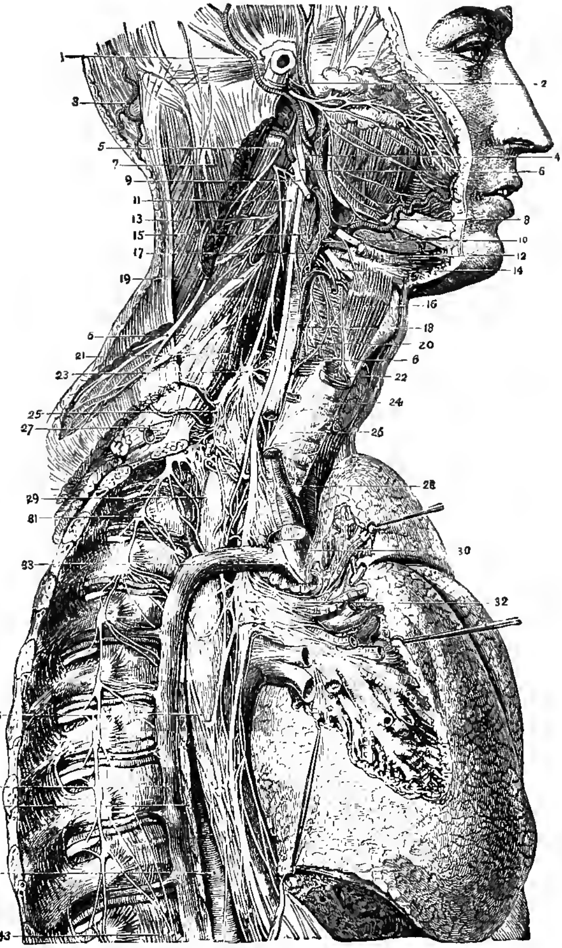
Posterior Divisions of the Dorsal Nerves.—The posterior divisions of the dorsal nerves supply the muscles of the spine, the joints of the spinal column, the membranes of the cord, and skin of the back (fig. 233). Each nerve passes backwards between two transverse processes, with the superior costo-transverse ligament to its outer side and the capsule of the articular processes to its inner side. Each nerve divides on the longissimus dorsi, the *inner* branch passing to the dorsal surface on the inner side of the muscle, the *outer* on the outer side (fig. 233). The upper six internal branches end as the *posterior cutaneous nerves*; in the lower six they come from the external branches.

Thus it will be seen that the twelve pairs of dorsal nerves supply the trunk, thoracic and abdominal walls (both skin and muscles), between the neck above and the groin below. Each pair of dorsal nerves, through the posterior, lateral and anterior cutaneous branches, supply a circular belt of skin or cutaneous segment of the body.

Nerve Supply of the Thoracic and Abdominal Viscera.—The dorsal nerves supply visceral branches to all the organs of the thorax, to the abdominal viscera, excepting those of the pelvic region, and to certain structures in the head and neck. These nerves, emerging by the white rami communicantes (fig. 234), pass in the sympathetic ganglia and cord and splanchnic nerves to the sympathetic plexuses in the thorax, abdomen, and head and neck. It will thus be noted that the viscera of the thorax and abdomen are supplied by the same nerves as supply the containing walls.

Rami Communicantes.—Each dorsal nerve gives off, as it emerges from the intervertebral foramen, a white ramus

FIG. 234.—THE NERVE SUPPLY OF THE THORACIC AND ABDOMINAL VISCERA. (*Hirschfeld and Leveillé.*)



1. Posterior auricular artery. 2. Temporal artery. 3. Occipital artery. 4. Glosso-pharyngeal nerve. 5, 5. Spinal-accessory nerve. 6, 6. Pneumogastric nerve. 7. Sterno-mastoid (cut). 8. Facial artery. 9. Hypoglossal nerve with communication from second cervical nerve. 10. Lower end of ditto. 11. Superior cervical ganglion of sympathetic. 12. Digastric. 13. Third cervical nerve. 14. Superior laryngeal nerve. 15. Internal carotid. 16. Thyro-hyoideus. 17. External carotid. 18. Common carotid. 19. Fourth cervical nerve. 20. Inferior constrictor of pharynx. 21. Phrenic nerve on scalenus anticus. 22. Crico-thyroideus. 23. Middle cervical ganglion. 24. Trachea. 25. Thyroid axis. 26. Recurrent laryngeal nerve. 27. Subclavian artery. 28. Innominate artery. 29. Œsophagus. 30. Vena cava superior (cut). 31. Gangliated cord of sympathetic. 32. Posterior pulmonary plexus. 33. Phrenic nerve (cut). 35. Œsophageal plexus. 37. Vena azygos major. 39. Thoracic duct. 41. Thoracic aorta. 43. Great splanchnic nerve.

communicans to the ganglion situated over the head of the rib below the foramen and beneath the pleura (fig. 234). The ganglion gives back to the nerve a grey ramus.

Sympathetic Ganglia and Cord.—There are twelve ganglia on each side (fig. 234). The upper ones lie over the heads of the ribs, but the lower ones approach the bodies of the vertebræ. The first lies below the head and neck of the first rib, and is often partially fused with the last cervical ganglion. The chain or cord between these two ganglia surrounds the subclavian artery, and forms the annulus of Vieussens. Through this part of the chain, nerve fibres stream up to the eye and to the glands of the head and neck (fig. 234, 27).

Thoracic Splanchnics.—From the upper four or five ganglia, splanchnic nerves pass into the posterior mediastinum, where they will be followed later (fig. 234). They end with branches of the vagus in the aortic and pulmonary plexuses, supplying vaso-motor nerves to the lungs. They are also the sensory pathways for those organs.

Abdominal Splanchnics (fig. 173, p. 118).—These are examined by the dissectors of the abdomen and are three in number.

(1) The *great splanchnic* arises from the ganglia of the sixth, seventh, eighth, and ninth nerves. It passes down beneath the pleura on the bodies of the vertebræ. It pierces the crus of the diaphragm and ends in the semilunar ganglion.

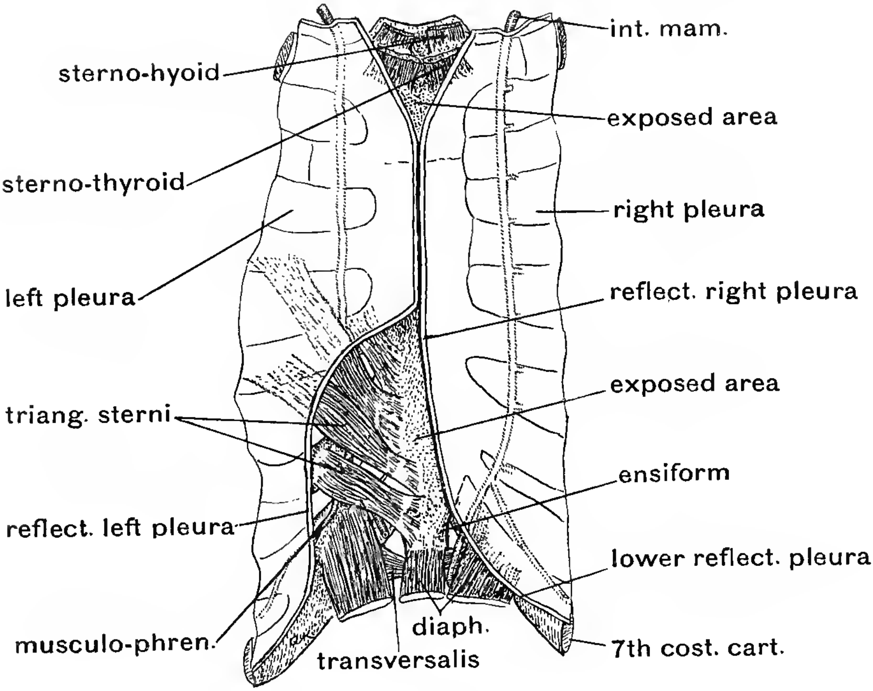
(2) The *small splanchnic* nerve arises from the sympathetic ganglia of the tenth and eleventh nerves. It passes through the crus or under the internal arcuate ligament, and ends in the semilunar ganglion and renal plexus.

(3) The *smallest splanchnic* nerve accompanies the last to the renal plexus; it arises from the last dorsal ganglion.

The oblique upward course taken by the upper intercostal vessels is due to the descent of the heart pulling the aorta downwards after it. The thoracic origin of the abdominal splanchnic nerves is owing to the fact that the abdominal viscera were developed in front of the lower seven dorsal vertebræ. The lungs are developed later and push the abdominal viscera backwards from their original position.

Lymphatics of the Costal Wall.—The lymphatic vessels in the costal wall of the thorax accompany the veins. They drain the parietal pleura and form a rich plexus in the sub-pleural tissue. In front they end in the anterior intercostal glands, which lie on each side of the internal mammary artery. They end behind in the posterior intercostal glands, between the heads of the ribs, and in the glands of the posterior mediastinum. On the right side the lymphatics from the upper surface of the liver join those of the diaphragm, and end in the mediastinal glands. The lymph of the right side of the thorax passes to the right lymphatic duct; on the left side, to the thoracic duct.

Fig. 235.—The posterior aspect of the sternum, showing the origin of the triangularis sterni, diaphragm and reflection of the pleuræ.



Triangularis Sterni (fig. 235).—Origin. From the side of the ensiform process and lower part of the sternum.

Insertion.—To the inner aspects of the third, fourth, and fifth ribs. The points of insertion correspond with the points of origin of the pectoralis minor.

Nerve Supply.—From the intercostal nerves.

Action.—This muscle is not well developed, being partly fibrous, and evidently in a retrograde condition. If the sternum is fixed it depresses the ribs; if the ribs are fixed, it elevates the sternum.

The triangularis sterni is a continuation into the thorax of the transversalis abdominis, the origin of the diaphragm separating them (fig. 235). It separates the pleura from the costal cartilages. The internal mammary artery lies between it and the cartilages.

Subcostal Muscles.—These irregular muscle slips will be seen lying beneath the pleura on the posterior aspect of the costal wall, crossing one or two ribs. They are attached to the inner aspect of the ribs, and belong to the same layer as the transversalis abdominis and triangularis sterni.

DISSECTION II

THE LUNGS AND PLEURÆ

The Cavity of the Thorax is now seen to be divided into the following three parts (fig. 236):

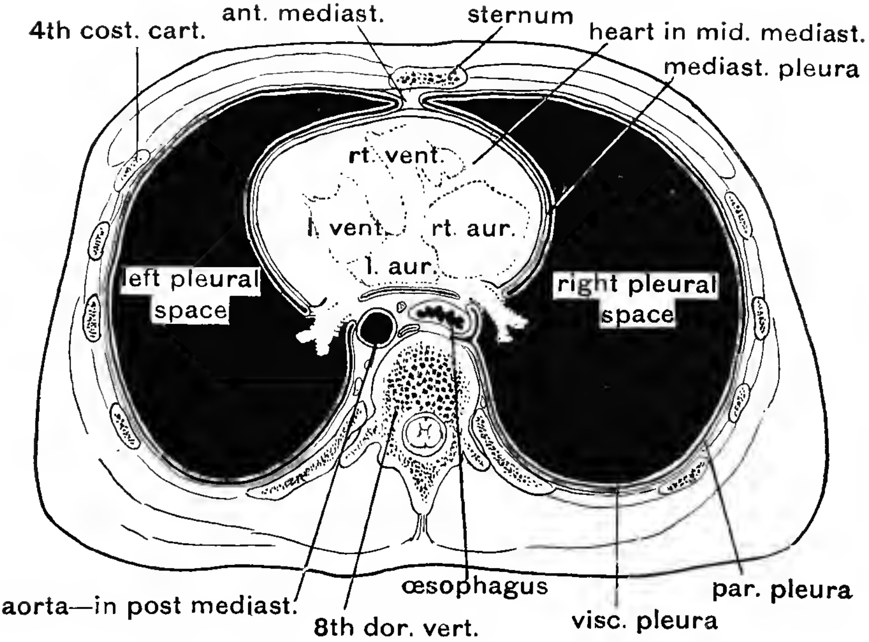
(1) Right pleural space, containing the right lung.
(2) Left pleural space, containing the left lung.
(3) The mediastinal space (mediastinum), between the two pleural spaces. It contains the heart, great vessels and structures passing between the neck and abdomen (fig. 236).

THE PLEURÆ

Visceral and Parietal Pleuræ.—In life each lung fills its pleural cavity; the surface of the lung, covered by the *visceral* pleura, is in apposition with the walls of the pleural cavity lined by the *parietal* pleura (fig. 236). The bronchus, the pulmonary arteries, veins, nerves, and lymphatics enter at the inner side of the lung and form its root (fig. 237). On the root of the lung, and for some distance below it, the visceral and parietal pleuræ become continuous. Only there are they continuous in health; but, as a result of disease (pleurisy), the parietal and visceral pleuræ may adhere in patches or entirely.

Sub-pleural Tissue and Sub-pleural Plexus.—The parietal pleura, except on the diaphragm, is loosely bound down by sub-pleural tissue. In the tissue there is a rich plexus of vessels which nourish the pleura. The vessels are derived from every artery and vein that supply the walls of the thorax. There is also a very rich network of lymphatic vessels in communication by stomata with the surface of the pleural space. The *visceral pleura* cannot be peeled from the surface of the lung, so firmly is it bound down. The visceral sub-pleural plexus is supplied from the bronchial vessels ; the lymphatics are numerous, and are marked by minute patches of soot and dust which have passed into them from the air alveoli.

Fig. 236.—Diagrammatic transverse section of the thoracic cavity, showing its division into three compartments.

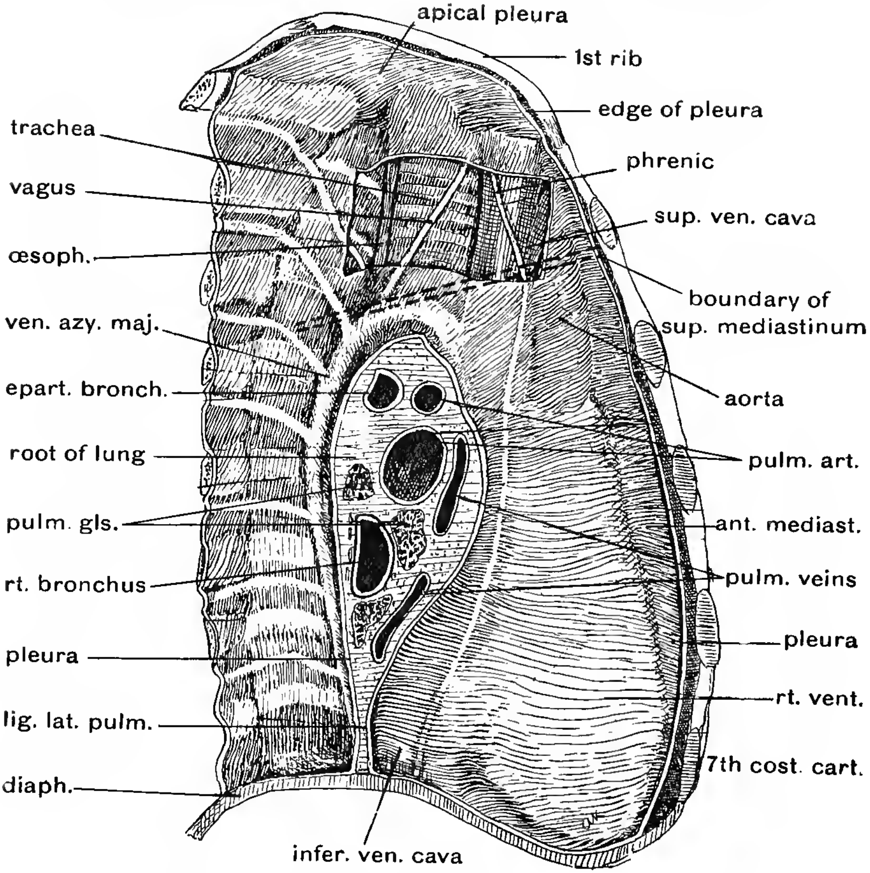


Parietal Pleura.—The parietal pleura lines the pleural space in which the lung is contained. It consists of four parts : (1) Costal ; (2) Diaphragmatic ; (3) Cervical ; (4) Mediastinal.

The Costal Pleura lines the inner aspect of the costal wall, covering the lateral part of the spinal wall behind and sternal wall in front (fig. 236).

The Diaphragmatic Pleura covers the dome-shaped parts of the diaphragm which form the floors of the two pleural spaces. It becomes continuous with the costal pleura at the attachment of the diaphragm (fig. 238).

Fig. 237.—Diagram of the mediastinum from the right side, showing its divisions. The structures in the root of the lung are also shown.



The Cervical Pleura lines the apical fibrous dome (Sibson's fascia) (fig. 237). It is continuous with the costal pleura at the upper border of the first rib, and lies above the level of that rib and behind the sternal third of the clavicle.

Mediastinal Pleura (fig. 237).—The mediastinal part of each pleural sac stretches from the sternal to the spinal wall of the thorax. Between the mediastinal pleuræ lies the mediastinum, a space containing the heart and structures passing to and from it, the œsophagus, thoracic duct, and vagus nerves (fig. 236). Above, the mediastinal pleura is continuous with the cervical; below it joins the diaphragmatic; on the spinal and sternal walls it is continuous with the costal pleura. The root of the lung pierces it; on the root of the lung it is continuous with the visceral pleura (fig. 237).

Ligamentum Latum Pulmonis.—When the basal part of the lung is pulled away from the mediastinum, a fold of pleura will be seen uniting the mediastinal and visceral pleuræ. It is continuous with the pleura on the root of the lung above; its free lower edge lies above the diaphragm (fig. 237).

Pleural Villi and Appendices.—In the recesses or fornices between the diaphragmatic and costal pleuræ, small triangular free folds of the membrane may be seen. They often contain much fat. On their edges occur villi.

Structures seen beneath the Right Mediastinal Pleura (fig. 237).—(1) Nerves. (*a*) The phrenic passes down on the superior vena cava and heart, in front of the root of the lung. (*b*) The vagus is seen passing downwards on the side of the trachea, then behind the root of the lung (fig. 234).

(2) Heart and Vessels (fig. 237).—The superior and the intra-thoracic part of the inferior vena cava (half an inch in extent). Behind the last vessel there is a small pleural recess. The right auricle and part of the right ventricle within the pericardium. The right aspect of the ascending aorta and its innominate branch.

(3) The Œsophagus passes down in front of the spinal wall. Only its lower part is not in contact with the right pleura (fig. 238).

(4) The Trachea.

(5) The lower part of the Thoracic Duct.

(6) The Vena Azygos Major (fig. 237).

Structures beneath the Left Mediastinal Pleura (fig. 230).—(1) Nerves. As on the right side.

(2) Heart and Blood-vessels.—The left ventricle and part of the right; part of the left auricle and pulmonary artery, all within the pericardium. The left aspect of the aortic arch

and descending aorta. The left carotid and subclavian arteries; the left innominate vein.

(3) The Œsophagus, which is seen at the upper and lower parts only.

(4) Trachea.

(5) The Thoracic Duct above.

(6) The Left Superior and Inferior Azygos Veins. The Left Superior Intercostal vein.

The Sternal Reflection of the Mediastinal Pleuræ.—From the insertion of the second pair of cartilages to the insertion of the fourth pair, the right and left mediastinal pleuræ are in contact, and form a membrane or mesentery between the heart and the sternum (fig. 235). Here the anterior edges of the lungs pass under the sternum. Behind the manubrium, the mediastinal pleuræ diverge, each passing to the cervical pleura behind the sternal insertion of the first rib. Between them are situated remnants of the thymus and lymphatic glands. The pericardium projects most to the left side, and carries the left pleura an inch or more away from the sternum beneath the fourth and fifth intercostal spaces (fig. 226, p. 220). The right pleura passes down behind the sternum to the insertion of the sixth costal cartilage.

The Position of the Pleuræ and Lungs on the Surface of the Thorax (see fig. 223, p. 215).—The diaphragm forms the thoracic floor and abdominal roof. Its upper surface is covered by the diaphragmatic parts of the two pleuræ and the diaphragmatic part of the parietal pericardium (fig. 238). On it rest the concave bases of the lungs and diaphragmatic surface of the heart. Its lower surface is covered by peritoneum, and rests on the liver, stomach, spleen and kidneys (figs. 185 and 185a, p. 146). The surface marking of the diaphragm, then, is a matter of the utmost importance, seeing that it marks the limits of so many organs, among them the lower limits of the pleuræ and lungs.

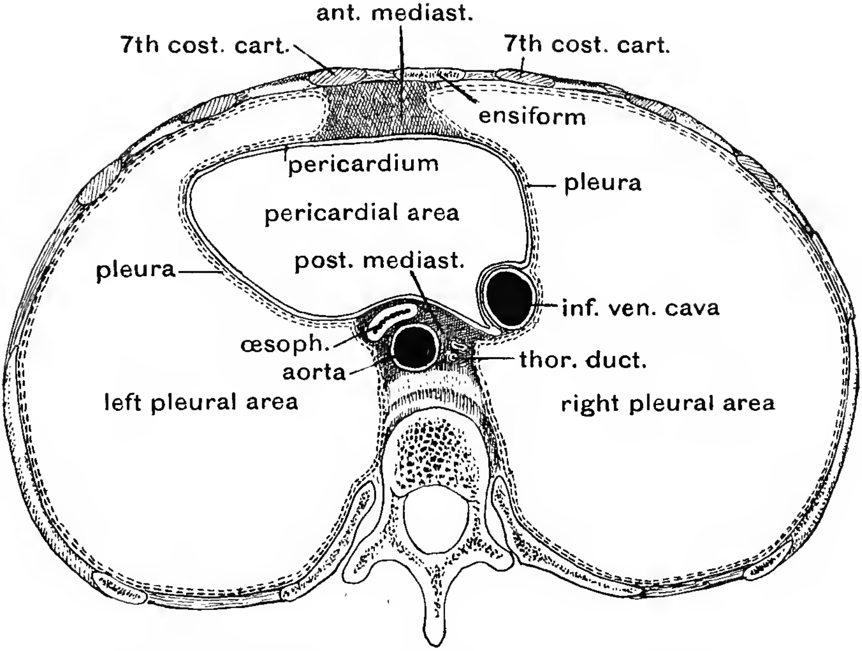
The Position of the Diaphragm.—The position of the diaphragmatic domes has already been indicated (fig. 223, p. 215). The line of its costal attachment indicates the lower limit of the pleuræ—the point at which the costal unites with the diaphragmatic pleura. The attachment of the circumference of the diaphragm is indicated thus:

(1) The sternal insertion of the seventh pair of costal cartilages and the cartilages themselves indicate the diaphragmatic attachment in front.

(2) The tip of the twelfth dorsal spine and the position of the spinal ends of the twelfth pair of ribs are found and marked to indicate the level of the diaphragmatic attachment behind.

(3) An oblique line on each side of the chest, uniting the outer ends of the seventh costal cartilages with the tip of the twelfth dorsal spine, indicates approximately the line of the diaphragm and lower limit of the pleura. The margin of the lung reaches within an inch of the pleural line during inspiration. Below the line of the lung, the costal and diaphragmatic pleuræ are in contact.

Fig. 238.—Diagram of the relations of the thoracic aspect of the diaphragm.



The position and relations of the cervical and sternal surfaces of the pleura have been already indicated (see pp. 240 and 242).

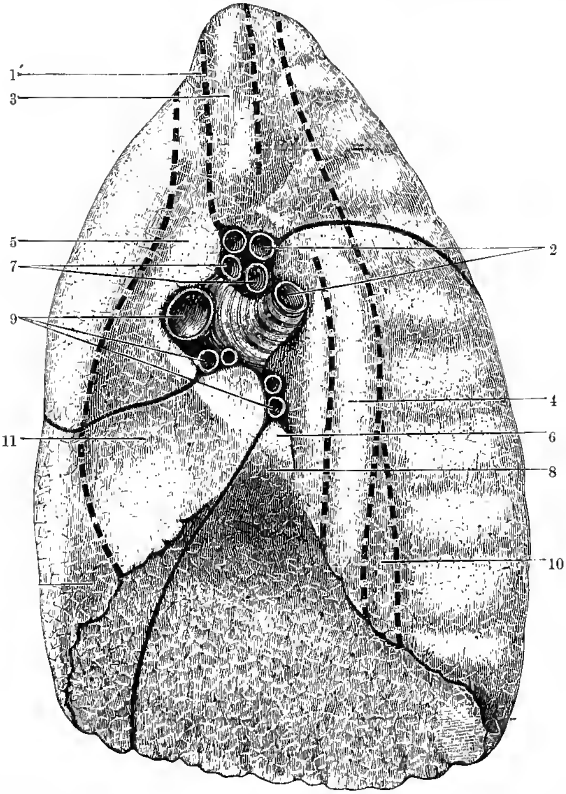
THE LUNGS

The lungs fill accurately the pleural spaces; they present the same surfaces as the parietal pleura, and are, like the cavities they fill, irregularly conical in shape.

Each lung presents the following **Surfaces** (figs. 239 and 240):

(1) Costal.—The visceral pleura covering this surface of the lung lies against the costal pleura and the structures of the costal wall of the thorax. It fills the concavity of the costal wall, which, it will be remembered, is specially marked behind at the angles of the ribs (fig. 236). The *posterior or vertebral border* of this surface is rounded and long, lying in contact with the bodies of the vertebræ from the first to the eleventh. The *anterior margin* is sharp, short, and lies under

Fig. 239.—The inner aspect of the right lung, showing its relations to the structures of the mediastinum. (*Anderson; after His.*)



1. For right innominate vein. 2. Bronchi. 3. For trachea. 4. For œsophagus (the position is indicated above, but there is no distinct impression above the hilum). 5. For lower end of vena cava superior. 6. For left auricle. 7. Veins. 8. For vena cava inferior. 9. Arteries. 10. For aorta. 11. For right auricle and right ventricle (latter below).

the edge of the sternum from the second to the sixth cartilages on the right side, and from the second to the fourth on the left. The anterior border of the left lung is notched below where it lies beneath the fourth and fifth spaces and over the pericardium (see fig. 223, p. 215).

(2) DIAPHRAGMATIC.—This surface is concave, and caps the dome of the diaphragm and the abdominal contents of the dome. The surface is directed forwards and downwards. Its *outer* or *costal margin* is convex, sharp, and lies in the recess between the costal and diaphragmatic pleuræ. Its inner or mediastinal margin lies at the junction of the mediastinal and diaphragmatic pleuræ.

(3) MEDIASTINAL.—This surface is in contact with the mediastinal pleura and the structures beneath it (figs. 237, 239, 240). Distinct impressions on this surface of the *right lung* are to be seen for the right auricle, superior and inferior venæ cavæ. The arch of the aorta, the innominate, and part of the right ventricle also are in contact with it. On the *left lung* there is a deep cardiac impression, into which the left half of the heart projects. The posterior border of its mediastinal surface is grooved by the descending aorta, the left carotid and subclavian vessels; the œsophagus above and below (fig. 240).

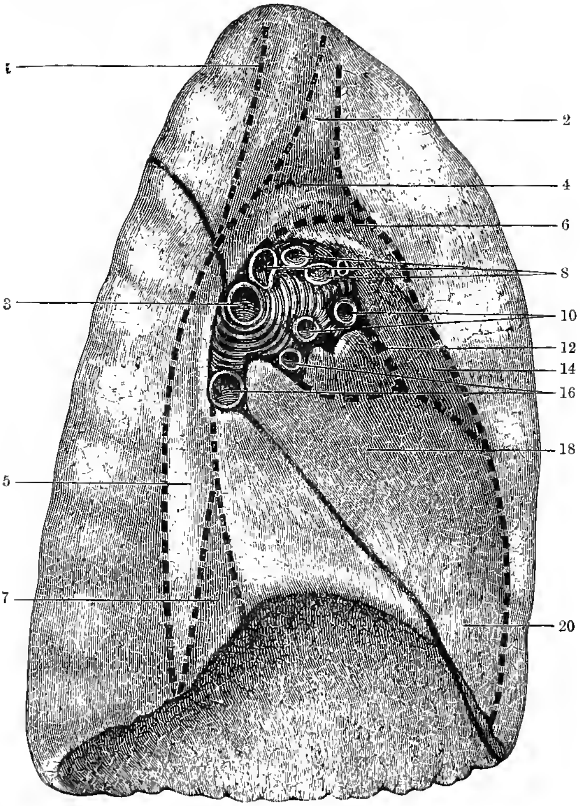
(4) CERVICAL OR APICAL.—It is continuous with the costal and mediastinal surfaces opposite the inner margin of the first rib. It is in contact with the cervical parietal pleura and projects above the first rib. The subclavian vessels groove it.

The encroachment of the liver on the floor of the right pleural space makes the right lung the shorter of the two; the encroachment of the heart on the mediastinal wall of the left pleural space makes the left lung the narrower of the two.

Lobes of the Lung.—The right lung is divided by two fissures, the *oblique* and *transverse*, into three lobes—upper, middle, and inferior (fig. 239). The left lung is divided into upper and lower lobes by the *oblique fissure*. The upper and middle lobes of the right side correspond to the upper lobe of the left side. The upper lobe may be affected in disease while the lower is free; the position of the oblique fissure of each lung on the surface of the thorax is therefore important.

The *oblique fissure* commences opposite the third dorsal vertebra (second dorsal spine) and ends below at the costal or lower margin of the lung, near the sternal end of the sixth costal cartilage. On the left side it terminates an inch further from the sternum than on the right side. The position of the fissure cutting off the middle from the upper lobe of the right lung is indicated by a line drawn from the insertion of the third right cartilage to the mid-point of the line of the oblique fissure. The pulmonary fissures are frequently partly or completely closed, commonly by disease; sometimes they are not developed.

Fig. 240.—Inner aspect of the left lung, showing its relations to the structures of the mediastinum. (*Anderson; after His.*)



1. Position of œsophagus and trachea (no impression). 2. For left common carotid artery. 3. Bronchus. 4. For arch of aorta. 5. For dorsal aorta. 6. For pulmonary artery. 7. For œsophagus. 8. Veins. 10. Arteries. 12. For right auricular appendage. 14. For right ventricle and pulmonic sinus arteriosus. 16. Arteries. 18. For left ventricle. 20. For cardiac apex.

Characters of the Pulmonary Tissue.—The *elasticity* of the pulmonary tissue is well seen in the collapse of the lung on the admission of air to the pleural space; the elasticity of the lung plays a considerable part in emptying the lung in expiration. It feels spongy; the air in the vesicle crackles when the pulmonary tissue is rubbed between the fingers. Normal and healthy lung floats in water.

Structures which enter and leave the Lung.—The lungs are free except at a part of their mediastinal surface, where structures enter and emerge from it (fig. 237). These structures form the *root* of the lung; they are enclosed by a sheath of pleura continuous with the mediastinal and visceral pleura, and with the folds of the ligamentum latum pulmonis below.

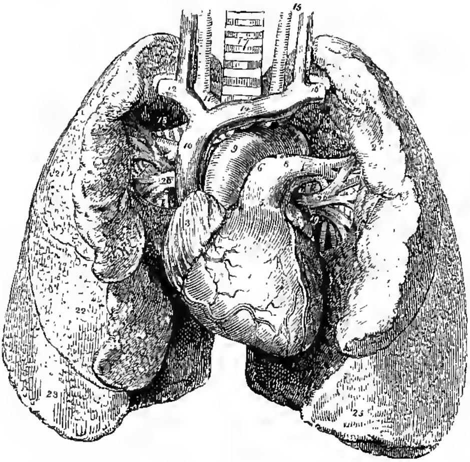
Root of the Lung.—Each root is made up of (fig. 237):

(1) Pulmonary Veins.
(2) Pulmonary Artery.
(3) Bronchus.
(4) Nerves.
(5) Lymphatic Vessels and Glands.
(6) Bronchial Arteries.
(7) Connective Tissue.
(8) A sheath of pleura.

Pulmonary Veins (fig. 241).—Within the lung the blood becomes arterialised. The first structures encountered when the pleura is reflected from the front of the root of the lung are the two *pulmonary veins* (fig. 241, 20); they convey the arterial blood from the lungs to the left auricle. By the use of the scalpel handle they can be seen to enter this cavity at the back of the heart. They leave the lung in front of and rather below the other structures, except some tributaries of very considerable size which emerge as the most posterior structures of the root.

Pulmonary Arteries (fig. 241).—Behind and above the veins will be found the pulmonary artery, the vessel which brings the venous blood from the right ventricle and distributes it to the capillary plexuses which surround the air vesicles of the lungs (fig. 241, 5, 6, 7). The arteries enter and divide in the root of the lung behind the veins, in front of and rather below the bronchus, but some branches pass behind the bronchi and enter the lung (fig. 240). The origin of the right and left pulmonary artery should be seen now. Make a window in the pericardial sac beneath the left mediastinal pleura. The pulmonary aorta will be seen within the sac, rising from the upper end of the right ventricle and bending backwards in front and to the left side of the systemic aorta (fig. 241, 5). It bifurcates into right and left pulmonary arteries as it perforates the posterior wall of the pericardium, above the base of the heart formed by left auricle. Hence the arteries appear at a higher level than the pulmonary veins, which end in that chamber. The right ventricle is the pulmonary pump, and keeps up the circulation through the pulmonary arteries and veins.

Fig. 241.—The heart and lungs. (*Wilson.*)



1. Right ventricle. 2. Left ventricle. 3. Right auricle. 4. Left auricular appendix. 5. Pulmonary aorta. 6. Right pulmonary artery. 7. Left pulmonary artery. 8. Remains of the ductus arteriosus. 9. Arch of the aorta. 10. Superior vena cava. 11. Innominate artery, and in front of it the right innominate vein. 12. Right subclavian vein, and behind it, the corresponding artery. 13. Right common carotid artery and jugular vein. 14. Left innominate vein. 15. Left carotid artery and jugular vein. 16. Left subclavian vein and artery. 17. Trachea. 18. Eparterial branch of right bronchus. 19. Left bronchus. 20, 20. Pulmonary veins. 21. Superior lobe of the right lung. 22. Middle lobe. 23. Inferior lobe. 24. Superior lobe of the left lung. 25. Inferior lobe.

Trachea and Bronchi.—The air enters and leaves the roots of the lung by the right and left bronchi. By the use of the handle of the scalpel the bronchi can be seen passing from the bifurcation of the windpipe or trachea in front of the fourth dorsal vertebra to the lung (fig. 241, 18, 19). They lie in the root behind and rather above the level of the pulmonary vessels, but minor branches of the pulmonary artery and vein will be found to enter the lung behind them. The right bronchus is rather larger and more horizontal than the left; it gives off as it enters the lung a branch (eparterial bronchus) to the upper lobe (fig. 237). These characters of the right bronchus give rise to a slight difference in the relationship of the structures of the two roots; the right bronchus lying rather above the level of the pulmonary artery, the left rather below it. The branch of the pulmonary artery to the upper right lobe passes under the bronchus; in all other cases the artery enters above its corresponding bronchus.

These three structures (pulmonary veins, artery, and bronchus) make up the main part of the root of the lung, and are concerned in the pulmonary circulation.

Nerves of the Lungs (figs. 230 and 234).—Each lung is supplied by nerves from two sources: (1) The vagi; (2) The sympathetic system. From these are formed the pulmonary plexuses. In front of the root of the lung will be found the *anterior pulmonary plexus*; behind it, the *posterior pulmonary plexus*.

The ANTERIOR PULMONARY PLEXUS is made up of branches from the vagus, which come off as that nerve passes behind the root. Other branches come from the third and fourth thoracic ganglia of the sympathetic. The plexus communicates by many twigs with the deep cardiac plexus.

The POSTERIOR PULMONARY PLEXUS is larger and more complicated than the anterior, and is made up from the same sources (fig. 234, 32). Bronchial glands lie imbedded in both anterior and posterior plexuses; these glands are frequently diseased.

From the anterior and posterior pulmonary plexuses, nerves stream into the lung on the structures of the root. They are both afferent and efferent in function.

Lymphatics.—The lymphatic system of the lung is extensive and elaborate. The lymphatic vessels are marked by black or grey sooty contents, absorbed from the air alveoli, and are arranged in the following manner: (1) The sub-pleural network; (2) septal lymphatics on the pulmonary fibrous septa which pass from the sub-pleural tissue to the sheaths of the larger bronchi near the root of the lung; (3) peribronchial vessels in the sheaths of the bronchi and bronchioles.

Bronchial Glands (fig. 237).—From the intra-pulmonary lymphatics the vessels stream through the root of the lung, and end in a most important group of glands—the bronchial. The bronchial glands are situated below, behind, and in front of the right and left bronchi, and in the bifurcation of the trachea. In disease of the lung they quickly become enlarged, and then press on the surrounding structures. They rest on the œsophagus, below the bifurcation of the trachea. Dust inhaled and absorbed by the lymphatics is arrested in these glands. Hence they are black. The lymph passes from these to the thoracic duct on the left side, to the right lymphatic duct on the right side.

Bronchial Vessels.—The tissue of the lung is supplied and nourished by the bronchial arteries. The right bronchial artery arises with the first right intercostal branch of the aorta. It passes with the bronchus into the lung and ramifies with it in the pulmonary tissue. On the left side, as a rule, there are two bronchial arteries which spring from the concavity of the arch of the aorta. Their distribution is similar to the vessel of the right side.

Only part of the blood conveyed by the bronchial arteries is returned by the *bronchial veins.* The right joins the vena azygos major, the left the superior left vena azygos.

Relations of the Roots of the Lungs (figs. 234, 237, 230).—*In front* of each root is the phrenic nerve and anterior pulmonary plexus. In front of the right root is the superior vena cava.

Behind each root are the vagus nerve, posterior pulmonary plexus, and descending behind the root of the left lung is the descending thoracic aorta.

Below the root is the ligamentum latum pulmonis on each side (fig. 237).

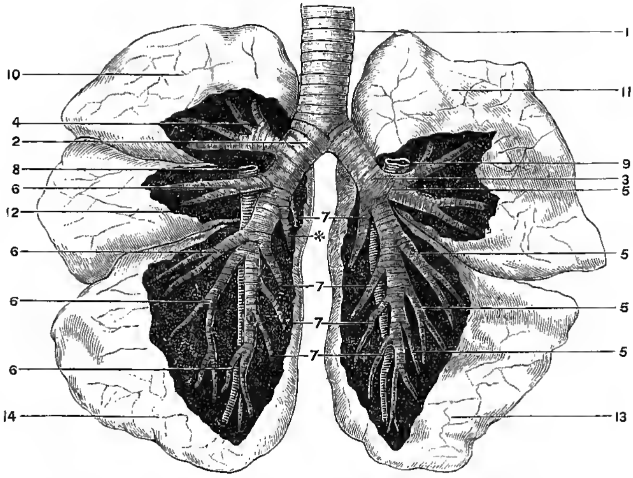
Above the root of the *right* lung is the terminal portion of the vena azygos major, and passing over the root of the *left* lung is the arch of the aorta.

Structure of the Lung.—The bronchus is to be followed into each lung and the manner of its ramifications studied (fig. 242). On the right side the eparterial bronchus comes off for the upper lobe of the right lung much earlier than the corresponding bronchus to the apex of the left lung. Each bronchus divides and redivides as it sinks deeper in the lung; the divisions are equal or nearly equal. The bronchial tubes to the apical division of the lung—the part above the level of the root—are directed upwards; those to the basilar division of the lung pass downwards and outwards. Those for the vertebral border are directed backwards and downwards. The pulmonary vessels accompany the ramifications of the bronchi.

The pulmonary septa of connective tissue, bronchial and vascular sheaths, pleural and sub-pleural coats have been already described. These are best seen on making a section of the lung. In fibroid phthisis the pulmonary septa passing from the bronchial sheaths to the sub-pleural capsule of the lung undergo contraction.

Anatomical Basis of Respiration.—The root of the lung and the ligamentum latum pulmonis are divided on each side and the lungs removed (fig. 237). Before proceeding to the next dissection, the student should briefly review the manner in which the capacity of the pleural spaces, and consequently the lungs, are enlarged on inspiration. It is clear that the pleural space cannot be enlarged by a movement of its mediastinal wall. The cervical wall also is nearly fixed; the scalene muscle may act on it slightly. On the other hand, the costal and diaphragmatic walls are movable, the diaphragmatic by far the most so.

Fig. 242.—The ramification of the bronchi within the lungs. (*Heath, after Aeby.*)



1. Trachea. 2. Right bronchus. 3. Left bronchus. 4. Eparterial bronchus to right upper lobe, above pulmonary artery; no corresponding branch on left side. 5, 5, 5, 5. Left ventral branches, four in number, the upper going to upper lobe. 6, 6, 6, 6. Right ventral branches, four in number. 7, 7, 7, 7. Dorsal branches, right and left, four in number, the upper going to the middle lobe. * A branch found only on the right side, corresponding to that going to the azygos lobe of most animals. 8. Right pulmonary artery. 9. Left pulmonary artery. 10. Right upper lobe. 11. Left upper lobe. 12. Right middle lobe. 13. Left lower lobe. 14. Right lower lobe.

When the diaphragm contracts, the capacity of the pleural space, and therefore of the lung, increases in every diameter. The pleural floor becomes less convex; it comes nearer to forming a level plane between its sternal attachment in front and its spinal attachment behind. All the parts of the diaphragm, however, are not equally movable; the middle or mediastinal part (fig. 238) is practically fixed and can undergo only the slightest degree of movement. The lateral parts forming the pleural floors are, on the other hand, freely movable. When they descend in inspiration, the lungs expand and the abdominal structures occupying the diaphragmatic domes (liver, stomach, spleen, &c.) are pushed forwards and downwards against the abdominal walls, which return them and restore the convexities of the pleural floors in expiration.

The resistance offered by the abdominal viscera in inspiration causes the muscular fibres of the diaphragm to raise their costal points of attachment; the liver, for instance, acts as a fulcrum for the right dome; against this fulcrum the diaphragm contracts and raises its costal attachment as it pushes the liver down. Hence the diaphragm has a double action; it depresses the pleural floor and raises the costal wall of the thorax at the same time.

The movements of the costal wall also enlarge the pleural cavity. The ribs are so obliquely placed and bent, that if their sternal ends are raised the antero-posterior diameter of the chest is increased; if their angles are raised the transverse diameter is increased. These movements are executed in normal respiration by the diaphragm, the intercostal muscles, the levatores costarum, and serratus posticus superior.

It must not be forgotten that the costal attachments of the diaphragm are stayed by every muscle taking part in the formation of the belly-wall. The abdominal muscles are the opponents of the diaphragm, and, next to it, must be reckoned as the chief muscles of respiration.

Of the three spaces into which the thorax is divided, the student has now examined two, viz. the pleural spaces which contain the lungs. It now remains for him to examine the third space and its contents, viz. the mediastinal.

DISSECTION III

THE MEDIASTINUM AND ITS CONTENTS

Boundaries of the Mediastinum.—The formation and contents of this space have been already reviewed and are now to be dissected and traced (p. 241). The mediastinal pleuræ are removed, the structures which they cover being noted. The mediastinum lies between the right and left mediastinal pleuræ (fig. 236, p. 239); the sternum bounds it in front, the bodies of the dorsal vertebræ behind; the mediastinal surface of the diaphragm limits it below (fig. 238); above it communicates with the neck by the superior mediastinal passage (fig. 224, p. 217).

Sub-divisions (fig. 237).—The mediastinum is divided into four parts: (1) The middle mediastinum is occupied by the pericardium and its contents; (2) the anterior mediastinum lies between the pericardium and sternum; (3) the posterior between the pericardium and the lower eight dorsal vertebræ; (4) the superior is situated above the anterior, middle, and posterior spaces. The plane separating the superior space from the lower three passes from the sternal insertion of the second pair of cartilages to the upper border of the fifth dorsal vertebra (see fig. 237).

The *anterior mediastinum* (fig. 235, p. 237) lies behind a small portion of the left half of the sternum, the left triangularis sterni, and the inner ends of the fifth and sixth left costal cartilages. It is bounded behind by the pericardium, and on each side by the pleura. It contains some areolar tissue and lymphatics (fig. 243). In many cases the line of the reflection of the left pleura is continued downwards, like the right, behind the sternum to the sixth costal cartilages, so as to obliterate the anterior mediastinum partially or completely.

The *middle mediastinum* (fig. 236) contains the pericardium, heart, and phrenic nerves.

The *superior mediastinum* (fig. 237) contains the arch of the aorta and its branches, the innominate veins and their tributaries, part of the superior vena cava, numerous bronchial and mediastinal lymphatic glands, the trachea, œsophagus and thoracic duct, the vagus, phrenic and left recurrent laryngeal nerves, cardiac branches of the vagus and cervical sympathetic, and some remains of the thymus gland (see fig. 222, p. 214).

The *posterior mediastinum* lies between the posterior surface of the pericardium and diaphragm and the lower eight dorsal vertebræ, and is limited laterally by the pleura (figs. 236 and 237). It contains the descending aorta and some of its branches, the œsophagus, thoracic duct, and azygos veins (major and minor), the great splanchnic nerves and some lymphatics.

Phrenic Nerves.—The right and left phrenics are the motor nerves of the diaphragm; they may also contain sensory fibres.

Course.—Each nerve passes through three distinct stages, viz. (1) cervical; (2) superior mediastinal; and (3) middle mediastinal. Its origin is in the neck from the fourth cervical nerve and also from the third and fifth.

The *cervical stage* lies on the scalenus anticus and subclavian artery (end of first stage) and behind the jugular and commencement of the innominate vein. It passes to the outer (sometimes inner) side of the origin of the internal mammary artery.

The *superior mediastinal stage* (fig. 237) lies beneath the pleura on the right innominate vein and superior vena cava on the *right* side. On the *left*, it lies beneath the pleura, between the left carotid and left subclavian arteries; it crosses the arch of the aorta internal to the vagus. Its course is on venous structures on the right and arterial on the left.

The *middle mediastinal stage* (fig. 237) lies beneath the pleura, on the pericardium, over the right auricle and on the inferior vena cava, on the *right* side; on the *left* it lies on the pericardium covering the ventricles, and thus diverges to the left as it passes to the diaphragm. Both nerves lie in front of the roots of the lungs and give off branches to the pericardium.

Each nerve enters and pierces the diaphragm, and ramifies beneath the peritoneum. There it communicates with nerves from the phrenic plexus.

The Vagi.—The right and left vagus nerves bring the viscera of the thorax, the respiratory and the upper part of the alimentary tracts into communication with nerve centres in the medulla oblongata. The effects on the heart, obtained by the stimulation of this nerve, are already familiar to the dissector from his physiological studies.

COURSE (see figs. 230 and 234).—Each vagus nerve passes through four stages in its course: (1) Cervical (see figs. 230 and 234); (2) superior mediastinal; (3) posterior mediastinal; (4) abdominal.

SUPERIOR MEDIASTINAL STAGE.—The *right* vagus enters the superior mediastinum in front of the right subclavian artery and behind the right innominate vein. It passes obliquely backwards on the side of the trachea, beneath the pleura, to reach the posterior aspect of the right bronchus (fig. 237).

The *left* vagus enters this stage between the left carotid and left subclavian arteries, and behind the left innominate vein. It crosses the arch of the aorta beneath the pleura, external to the phrenic nerve and the ductus arteriosus. It passes backwards to the posterior aspect of the root of the left lung, and lies behind the left bronchus.

POSTERIOR MEDIASTINAL STAGE.—Both nerves pass to the œsophagus, on which they descend, and enter the abdomen by the œsophageal orifice of the diaphragm. They form a plexus (plexus gulæ) on the œsophagus. The left nerve enters the abdomen in front of the œsophagus, the right behind it.

Branches (figs. 230 and 234).—In the superior mediastinal stage each are given off: (1) From the left vagus, the recurrent or inferior laryngeal branch, the motor nerve of the larynx. This branch turns round and ascends behind the subclavian artery on the right side, the ductus arteriosus and arch of the aorta on the left. On the right side the nerve rises from the end of the cervical stage.

(2) Thoracic cardiac branches. On the right side these branches arise from both the recurrent branch and the trunk nerve; on the left side they arise from the recurrent nerve. The branches pass to the deep cardiac plexus situated between the bifurcation of the trachea and aorta arch (figs. 230 and 234).

(3) Branches to enter into the formation of the anterior and posterior pulmonary plexuses.

(4) Œsophageal branches arise in the posterior mediastinal stage.

Mediastinal Lymphatic Glands.—These are most numerous in the superior mediastinum. The bronchial glands form the greater number of them. They are situated round the bronchi and in the bifurcation of the trachea.

In front of the arch of the aorta a number of cardiac glands will be found. Other glands lie on each side of the trachea and œsophagus. One or two are found in the anterior mediastinum, above the diaphragm. A number occur in the posterior mediastinum, which receive lymph from the œsophagus, diaphragm, and lower costal walls of the thorax.

Thymus Gland.—The thymus gland lies in the anterior part of the superior mediastinum. It reaches its fullest growth between the second and fifth years. After the twenty-fifth year it is represented by a fibro-glandular mass of tissue in front of the pericardium, the arch of the aorta and its branches. The thymus receives its blood supply from the internal mammary.

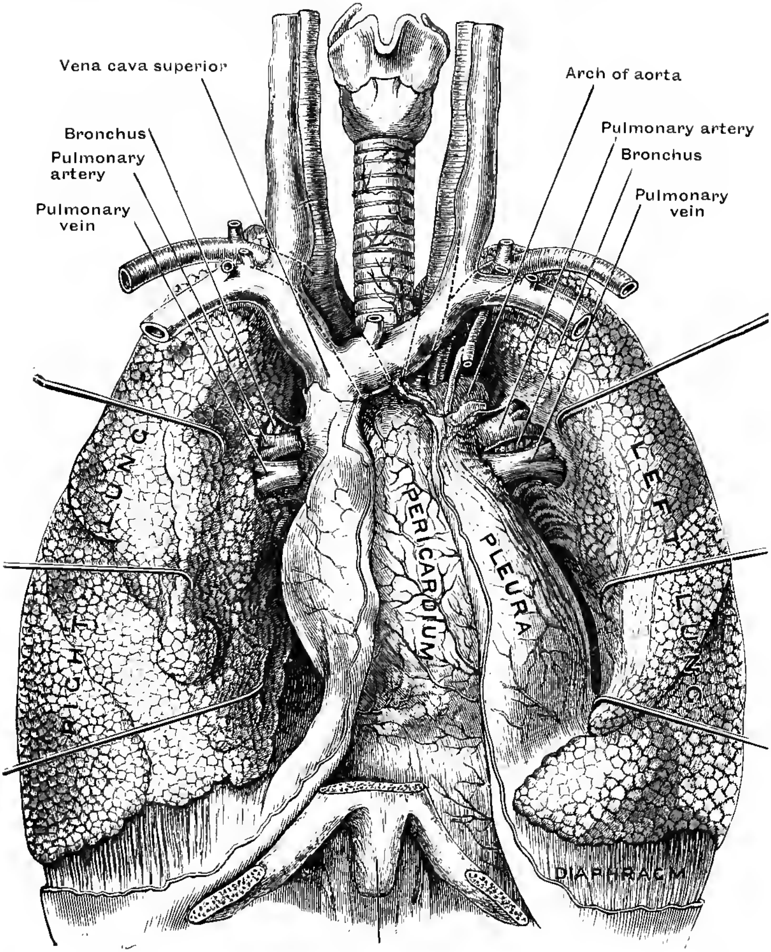
Venæ Cavæ.—The venous blood is returned to the heart by two great venous trunks—the superior and inferior venæ cavæ. In order to examine them the sternum is to be removed by dividing the insertions of the first and seventh pairs of ribs. It must be kept and replaced when the relationships of the heart are investigated.

Superior Vena Cava.—COURSE. The superior vena cava lies in the superior mediastinum, and returns the venous blood from the head and neck, upper extremities, and thoracic walls (fig. 243). It commences behind the right side of the manubrium sterni and second intercostal space above the second right costal cartilage, by the union of the right and left innominate veins (fig. 245). It ends in the right auricle, below the insertion of the third right costal cartilage. It passes down behind the right margin of the sternum, being partly hid by that bone. It has two stages—supra-pericardial and intra-pericardial. The vena azygos major arches over the root of the right lung and joins it at the junction of these two stages.

RELATIONSHIPS.—The *supra-pericardial stage* (fig. 243) is covered on its right and anterior aspects by the right pleura. The phrenic nerve descends on its outer aspect, the vagus nerve behind it. The innominate artery and commencement of the transverse aortic arch are on its left side and partly behind it.

The *intra-pericardial stage* is about an inch long. It is not free within the pericardium, as the student will see as he follows it into the sac (fig. 244). Its right surface is adherent to the pericardial wall; the rest is covered by the smooth visceral layer of pericardium. To the left is the ascending aorta; behind it are the structures entering the root of the right lung.

FIG. 243.—ANTERIOR VIEW OF THE LUNGS, PERICARDIUM AND GREAT VESSELS OF THE HEART. (*From Morris's 'Anatomy.'*)



The Innominate Veins (fig. 243).—The *right innominate vein* is about one inch in length, and is formed behind the sternal end of the right clavicle by the junction of the internal jugular and subclavian veins. It descends almost vertically to the level of the first right intercostal space, where it joins its fellow to form the superior cava. The clavicle and origin of the sterno-hyoid muscle lie in front of its commencement. It is clothed externally by the right pleura, the phrenic nerve intervening. The pneumogastric nerve descends behind the vein, and the innominate artery lies to its inner side.

The *left innominate vein* (fig. 243) is about three inches in length, and is formed behind the sternal end of the left clavicle by the junction of the left subclavian and internal jugular veins. From this point it descends obliquely towards the right, behind the upper part of the manubrium sterni and origins of the sterno-hyoid and sterno-thyroid muscles, just above the arch of the aorta. It joins its fellow to form the superior vena cava. In its course it crosses the left phrenic and pneumogastric nerves, the three great branches of the arch of the aorta, and the trachea. If the venous system is engorged, the vein may rise up on the trachea above the level of the manubrium sterni. In such conditions it may be wounded during the operation of tracheotomy.

Tributaries.—Each vein receives the inferior thyroid, the vertebral, the internal mammary and the vein of the first intercostal space. A large lymphatic trunk, the right lymphatic duct, enters it at the angle between the jugular and subclavian veins on the right side; the thoracic duct enters at the corresponding point on the left (fig. 176, p. 123).

The left vein receives in addition the left superior intercostal vein (fig. 232, p. 231).

Inferior Vena Cava.—The thoracic stage of the inferior vena cava is very short, being little more than half an inch. It enters the right auricle. Its relationship to the pericardium is peculiar (fig. 244). The vein perforates the pericardium obliquely. The right aspect lies outside that sac; the anterior, inner, and posterior aspects lie within the pericardium and are covered by the visceral layer. This can be seen by opening the pericardial sac. The right pleura covers the extra-pericardial part of the vein (fig. 237). The hepatic veins enter just before the vein perforates the diaphragm. There are no intra-thoracic branches. The sternal insertion of the sixth right costal cartilage marks on the surface of the chest the level at which the vein enters the right auricle. The vein returns the venous blood from the abdomen and lower extremities.

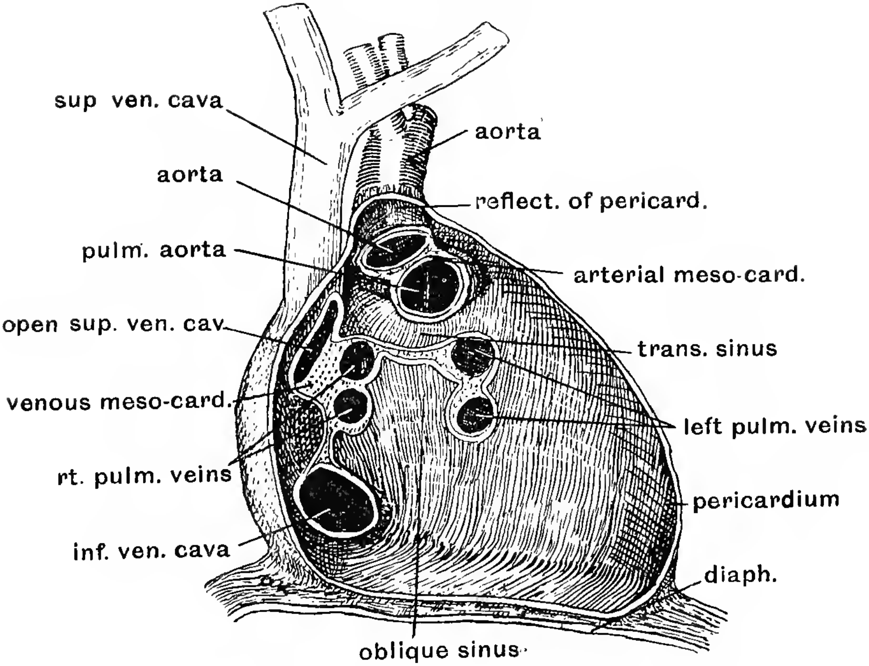
A GENERAL SURVEY OF THE HEART AND PERICARDIUM

The **heart** is composed of four chambers with muscular walls, viz.

1. Right Auricle.
2. Right Ventricle.
3. Left Auricle.
4. Left Ventricle.

Right Auricle (fig. 249).—The venæ cavæ empty the venous blood of the body into the right auricle of the heart. This is situated within the fibrous pericardium. When the pericardium is freely opened it is seen to hold a relation to it very similar to what has just been seen in the case of the venæ cavæ. There is a strip on its right posterior border, between the attachments of the superior and inferior venæ cavæ, which is adherent to the pericardium, and at which the serous covering of the heart becomes continuous with the smooth lining of the fibrous

Fig. 244.—The attachments of the heart to the posterior wall of the pericardium.



pericardial sac (fig. 244). The right auricle and venæ cavæ are thus bound to the fibrous pericardium by a structure to which the name of *venous meso-cardium* may be given (see fig. 244).

A thin sheath of fibrous tissue encloses the superior vena cava; it is continuous above with the cervical fascia, below with the fibrous pericardium. The inferior vena cava, its sheath and the pericardium are bound to the diaphragm. These structures help to retain the diaphragm, pericardium, and heart in a fixed position.

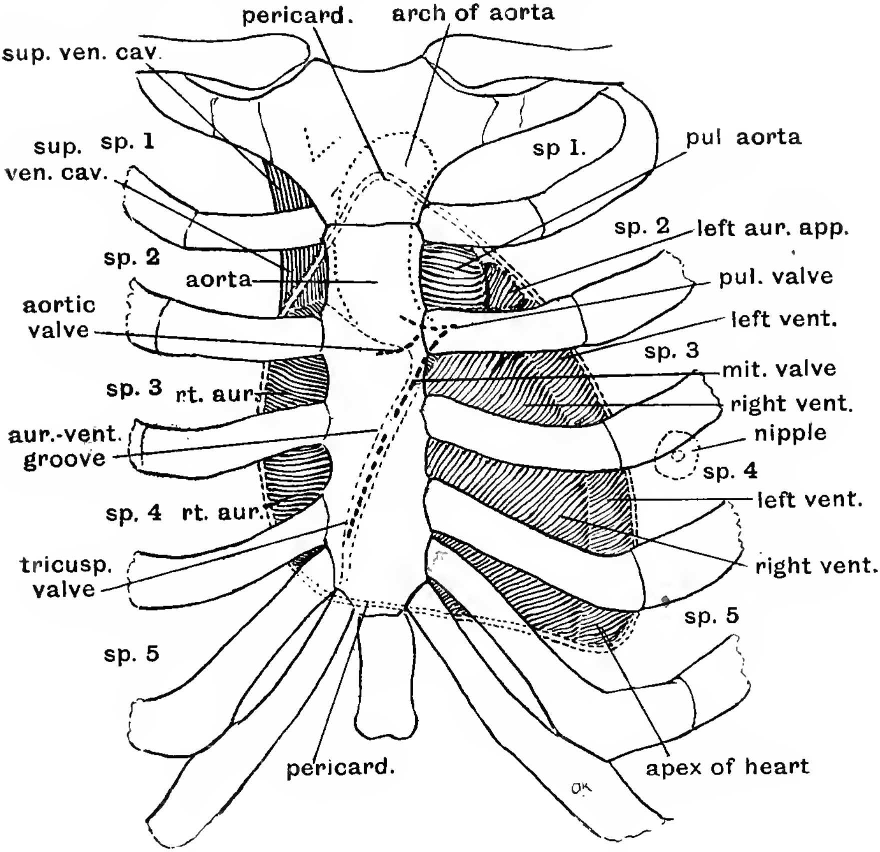
POSITION OF THE RIGHT AURICLE.—The superior vena cava has been seen to end behind the sternal insertion of the third right costal cartilage; the inferior opposite the sixth right; the right auricle lies between them, behind the inner inch of the fourth and fifth right intercostal spaces and behind the sternum (fig. 245). The auricular appendix lies behind the sternum, between the insertion of the third and fourth pairs of cartilages. The anterior border of the auricle, at the auriculo-ventricular groove, is oblique, passing across the sternum from the insertion of the fourth left to that of the sixth right costal cartilage (fig. 245). The right auricle forms the extreme right part of the heart, lying in front of the left auricle.

Course of the Blood through the Heart.—The venæ cavæ have just been followed to the first of the four chambers of the heart—the right auricle (fig. 245). The right auricle passes the blood into the right ventricle, through the right *auriculo-ventricular* orifice. This had better be examined now. Raise a triangular flap from the anterior aspect of the right auricle, with its apex at the auricular appendix and its base stretching between the venæ cavæ. When this flap is raised, and the contents removed, the opening to the right ventricle can be seen. The current of blood in the superior vena cava is directed towards it (fig. 252).

The RIGHT VENTRICLE has already been examined in connection with the lungs; it forces the venous blood received from the right auricle, through the pulmonary aorta, right and left pulmonary arteries, to the lungs. The right ventricle is triangular in shape, giving origin to the pulmonary aorta at its upper angle or *infundibulum* (fig. 252). When the right ventricle contracts, the blood would return to the right auricle were it not for the right auriculo-ventricular or *tricuspid valve*;

it would return from the pulmonary aorta were it not for the *pulmonary semilunar* valves. Both of these valves should be seen now, the first by raising the anterior wall of the right ventricle as a triangular flap, the base of the flap being as the auriculo-ventricular groove; the second by laying open the commencement of the pulmonary aorta by an anterior vertical incision, carried upwards from the upper angle of the ventricular flap. Much clot, and sometimes injected material, have to be removed with the handle of the scalpel to show the valves.

FIG. 245.—THE RELATION OF THE HEART TO THE WALL OF THE THORAX.



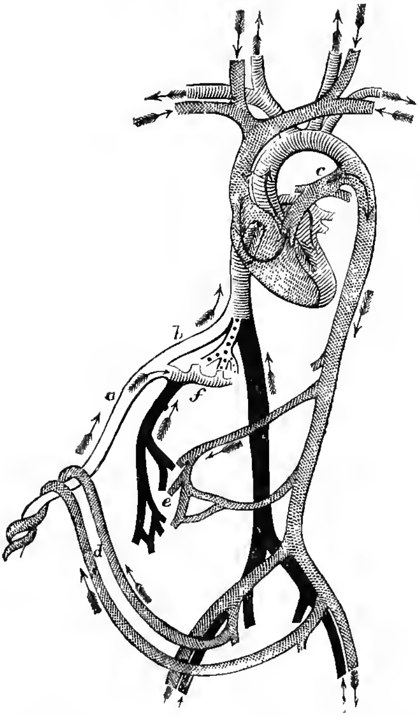
The arterial blood is returned from the lungs by the pulmonary veins, which have already been traced to the LEFT AURICLE. The relationships of these to the pericardium should be examined now. The left auricle forms the most posterior part of the heart (fig. 236, p. 239). It lies behind both ventricles and the right auricle. A narrow area of its posterior wall is attached to the pericardium. This attachment is part of the *venous meso-cardium* (fig. 244). The four pulmonary veins, as well as the two venæ cavæ, pierce the fibrous pericardium and enter the left and right auricles by the venous meso-cardium. When the apex of the heart is lifted up, this structure is seen attaching the heart and giving entrance to the veins. It is shaped like an inverted L, and bounds the *oblique sinus* of the pericardium (fig. 244).

The arterial blood passes from the left auricle to the LEFT VENTRICLE—the thick-walled pump of the systemic circulation. The left auriculo-ventricular orifice is guarded by the *bicuspid* or *mitral valve* (fig. 253). The arterial blood is forced by the left ventricle into the ascending aorta. It cannot regurgitate, owing to the *aortic semilunar valves*. The ascending aorta perforates the pericardium; it then becomes the *arch* of the aorta. The arch bends backwards and ends at the lower border of the fourth dorsal vertebra as the *descending* aorta. It is continued into the abdomen as the abdominal aorta. From it rise the arteries of the abdomen and lower extremities. From the arch arise the arterial trunks for the head and neck and upper extremities (fig. 243).

Relationship of the Pulmonary and Ascending Aortæ to the Pericardium.—The ascending aorta and pulmonary aorta lie within the pericardium, and are bound together in the same tube of the visceral layer (fig. 244). This may be seen by passing the finger backwards between the superior vena cava and the ascending aorta and bringing it out behind the pulmonary aorta. The finger then lies in the *transverse pericardial sinus* and above the left auricle. The two aortæ are bound together because both were parts of the same fœtal vessel—the bulbus arteriosus, the common aorta of the very early fœtal heart.

As the aortæ perforate the fibrous pericardial sac, the tubular *visceral* pericardium which covers them becomes continuous with the *parietal* pericardium lining the fibrous sac (fig. 244). This reflection forms the second bond between the heart and the pericardium, the *arterial meso-cardium.* The aortæ leave the pericardial sac in this meso-cardium. Thus it will be seen that the heart is bound to the pericardial sac by two mesocardia: the *venous*, at which the veins enter the auricles, and the *arterial*, by which the aortæ leave it. Further, the two right chambers of the heart have been seen to be pulmonary in nature, dealing with the venous blood; the two left chambers arterial or systemic, dealing with the arterial blood.

Fig. 246.—Diagram of the fœtal circulation. (*Wilson.*)



a. Umbilical vein. *b*. Ductus venosus. *c*. Ductus arteriosus. *d*. Hypogastric arteries. *e*. Termination of visceral arteries and commencement of portal system. *f*. Portal vein.

The arrows show the course of the blood-current.

Fœtal Circulation. There are certain features of the heart which will not be understood unless the dissector is familiar with the course taken by the blood in the heart up to the time of birth. This refers especially to two structures, the *fossa ovalis* (fig. 256, p. 283) and *ductus arteriosus* (fig. 246, *c*). Up to the time of birth there is no pulmonary circulation; there is then no air in the lungs, and the right ventricle acts, not as a pulmonary, but as a systemic pump for the body. The fossa ovalis and ductus arteriosus are the vestiges of fœtal communications which allowed the blood in the right side of the heart to pass to the systemic circulation without having to pass through the lungs.

The course of the arterial blood from the placenta to the inferior vena cava, through the umbilical vein and ductus venosus, has been already traced (see p. 112, fig. 172).

Foramen Ovale.—When the entrance of the inferior vena cava to the right auricle is examined, it will be seen that the current of blood entering by it must impinge against the posterior or septal wall which separates the right from the left auricle. On the septal wall will be seen the fossa ovalis. The *annulus ovalis* forms a rounded margin in front of and above the fossa (fig. 252, 7). In the adult the *septum ovale* forms the floor of the fossa. Up to the time of birth there is a free communication from the right to the left auricle, and the blood of the inferior cava (placental) passes through the foramen ovale (fig. 246). The *Eustachian valve* (fig. 256), a fold of endocardium which passes from the inner margin of the caval opening to the annulus ovalis, guides the blood from the inferior vena cava to the foramen ovale. The septum ovale projects upwards in the foramen and prevents the return of the blood. The opening not infrequently remains partially unclosed in the adult. By means of the foramen ovale, the inferior caval blood is short-circuited to the left auricle. From there it passes to the left ventricle, aorta, head and neck, upper extremities and remainder of the body (fig. 246).

Ductus Arteriosus (fig. 252, 26).—Between the left pulmonary artery and the arch of the aorta a short fibrous cord will be found round which the recurrent laryngeal branch of the left vagus nerve turns. This is the remnant of the ductus arteriosus.

The current of blood which enters by the superior vena cava in the fœtus is directed across the right auricle to the right ventricle, in front of the inferior caval or placental current (fig. 246). The right ventricle contracts, but the right and left pulmonary arteries are not yet open, and there is no exit to the lungs. The ductus arteriosus, a channel between the left pulmonary artery and end of the arch of the aorta, allows the right ventricle to throw its contents into the aorta. Thus, in the fœtus, both the right and the left ventricles are systemic pumps; both drive blood into the aorta. Because they have the same pressure to overcome, their walls are then of the same thickness. This is not so after birth. The right ventricle has lighter work than the left, and its walls are not half so thick (fig. 255). The ductus arteriosus is derived from the fifth left aortic arch of the embryo.

THE PERICARDIUM

It will now be possible for the student to follow a systematic description of the pericardium. The pericardium is the bursal sac of the heart. It consists of three parts :

(1) A *fibrous sac* (fig. 247), conical in shape; its base or floor is fixed to the diaphragm and its apex bound to the cervical fascia by the sheaths of the vessels in the superior mediastinum and slightly to the sternum by sterno-pericardial ligaments situated in the anterior mediastinum. It prevents distension of the heart and keeps it in position.

(2) The smooth lining of the sac or *parietal serous pericardium.*

(3) The smooth covering or *visceral serous pericardium* on the heart and intra-pericardial parts of the vessels. This is continuous with the parietal at two places, the venous and arterial mesocardia (fig. 244). As the heart beats the visceral layer rubs against the parietal. The surfaces are lubricated by a serous fluid.

Relations.—The pericardium presents an apex and five surfaces.

(1) The *apex* is perforated by the ascending aorta and superior vena cava (fig. 244). It lies in front of the bifurcation of the trachea and behind the sterno-manubrial joint (fig. 245).

(2) The *base or diaphragmatic* surface is bound to the diaphragm over the central tendon and, under the apex of the heart, for a little space beyond the central tendon. The inferior vena cava enters at its right posterior angle (fig. 238, p. 243).

(3) The *right pleural* surface is covered by the right pleura (fig. 243). The right phrenic nerve descends on it.

(4) The *left pleural* surface, covered by the left pleura ; it is much more extensive than the right (fig. 243).

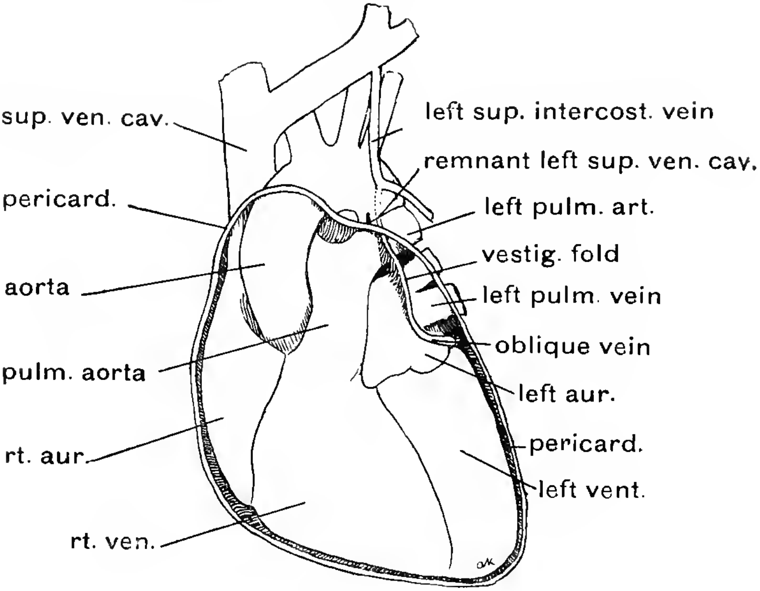
(5) The *anterior mediastinal* surface lies between the pleural surfaces. It is merely a line, except behind the inner inch of the fourth and fifth spaces of the left side and corresponding part behind the sternum (fig. 243).

(6) The *posterior mediastinal* surface, forming part of the anterior wall of the posterior mediastinum. It faces the bodies of the fifth, sixth, seventh and eighth dorsal vertebræ, and is in contact with the œsophagus, vagi, and descending aorta (fig. 261). The pulmonary vessels perforate it below the apex (fig. 244).

The *parietal pericardium* lines the fibrous sac. Its surfaces correspond with those of the sac.

The *visceral pericardium* covers the following parts (fig. 247): Both ventricles, both auricles, except where the venous meso-cardium is attached; parts of the venæ cavæ; the ascending and pulmonary aortæ. The *oblique sinus* covers the posterior aspect of the left auricle; the sinus forms a serous diverticulum between the heart and œsophagus. The *transverse sinus* covers the upper aspect of the left auricle (fig. 244).

FIG. 247.—THE VESTIGIAL FOLD OF MARSHALL.



Vestigial Fold of Marshall (fig. 247).—When the left superior vena cava existed in the early fœtus, it entered the pericardium and passed in front of the left root of the lung within a fold of serous pericardium in the same manner as the superior vena cava does in front of the right root. The fold of pericardium persists in front of the left root, although the left superior vena cava has disappeared, and forms the vestigial fold of Marshall. It will be found stretching between the intra-pericardial parts of the left pulmonary artery and vein.

Position of the Pericardium on the Surface of the Thorax (see fig. 245).—When the heart enlarges the pericardium is distended, or it may become dilated with fluid. Its normal limits are therefore important, and can be marked out on the surface of the thorax by the percussion of its contents. Normally it occupies a triangular area indicated thus:

(1) The *right margin* projects an inch beyond the right margin of the sternum, from the insertion of the second to the insertion of the sixth costal cartilages.

(2) The *lower margin* corresponds to the diaphragmatic line, drawn from the insertion of the sixth right costal cartilage to the apex beat in the fifth left space, 3½ inches from the margin of the sternum.

(3) The *left margin* is indicated by a line from the apex beat to below the second left costal cartilage, half an inch from the sternum. The *apex* of the pericardium lies between the second pair of costal cartilages.

THE HEART

The **heart** is composed of four muscular chambers or pumps, so combined together as to form an organ of rather conical form (fig. 249).

Surfaces (fig. 248).—After death it presents three surfaces and an apex:

(1) Diaphragmatic, resting on the diaphragm and formed by the ventricular part of the heart.

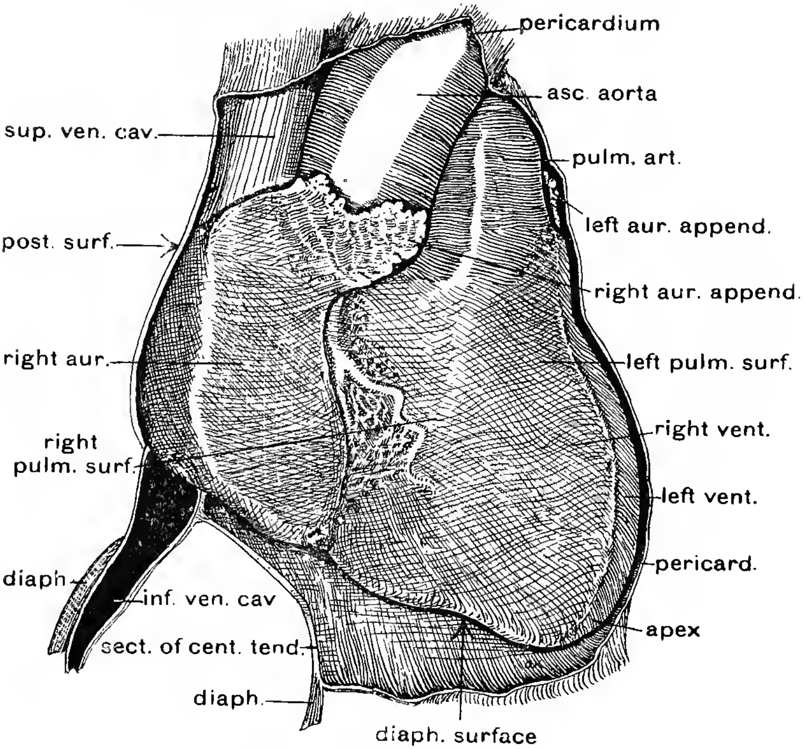
(2) Posterior or *basal,* directed towards the posterior mediastinum. The left auricle forms the greater part of it.

(3) A convex pulmonary or anterior surface, directed upwards and forwards, and to the right more than the left. Part is covered by the right lung, part by the left (right and left pulmonary areas). The right auricle, the appendix of the left auricle, and both ventricles, but the right more than the left, appear on this surface.

(4) The apex is directed towards the left. It is formed by the left ventricle, but it is the pulsation of the right ventricle that is felt over the area of the apex beat during life.

Position.—The *axis* of the heart passes from the basal surface to the apex. It passes obliquely forwards to the left and slightly downwards. The greater part of the right auricle, a small basal part of the right ventricle, and part of the left auricle lie to the right of the median plane of the body; the remainder, which forms two thirds of the heart, lies to the left of the median plane (fig. 245). Its base is directed backwards and towards the right, opposite the sixth, seventh, and eighth dorsal vertebræ. Its apex is directed forwards and towards the left, opposite the fifth left intercostal space, close to the junction of the bony and cartilaginous portions of the fifth costal arch.

FIG. 248.—THE RIGHT ANTERO-LATERAL ASPECT OF THE HEART.



GROOVES.—The heart is subdivided by grooves, which indicate the position of internal septa which divide the heart into its four cavities. These are the inter-ventricular and auriculo-ventricular grooves (figs. 248, 249, 250). Owing to a rotation of the heart towards the left side, the anterior inter-ventricular groove appears nearer to the left than the right border of the heart, and the posterior inter-ventricular groove is nearer the right than the left border. Consequently the anterior surface of the heart is formed mainly by the right ventricle and auricle, while the posterior surface is mainly formed by the left ventricle.

The inter-ventricular grooves meet at a point a little to the right of the apex, which is thus formed entirely by the left ventricle. The left border of the heart, *margo obtusus*, is formed by the thick wall of the left ventricle; and the right border, *margo acutus*, is formed by the much thinner wall of the right ventricle.

Position of the Heart with Reference to the Anterior Thoracic Wall.—The position of the heart can be indicated by four lines drawn on the chest-wall (fig. 245):

(1) A line drawn across the sternum, from the third left to the third right costal cartilage, represents the *upper limit* of the heart.

(2) The *right limit* of the heart is marked by a curved line from the third to the sixth right costal cartilage, the point of greatest convexity being about one inch from the sternum. This part marks the right border of the right auricle.

(3) The *lower limit* is indicated by a line drawn from the insertion of the sixth right costal cartilage across the sterno-xiphoid articulation to the apex point, 3½ inches from the sternum, in the fifth left intercostal space.

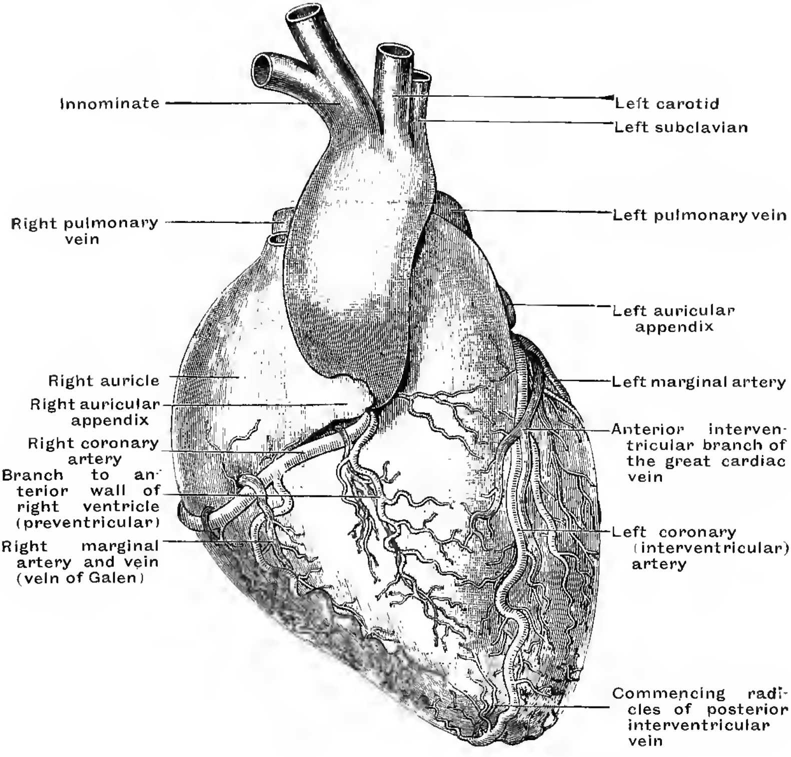
(4) The *left limiting line* is slightly curved, with its convexity towards the left, and is drawn from the apex point to the left of the upper limit, half an inch from the insertion of the third left costal cartilage.

Blood Supply of the Heart (figs. 249 and 250).—The heart is freely supplied with blood from the right and left coronary arteries. These lie beneath the visceral pericardium and in the cardiac fat filling the auriculo-ventricular and inter-ventricular grooves. It requires much pains to expose them clearly. The right will be found emerging in the auriculo-ventricular groove between the appendix of the right auricle and infundibulum of the right ventricle. The left appears between the appendix of the left auricle and pulmonary aorta. Each is accompanied by the coronary plexus of nerves, which passes thus to the substance of the heart.

The Coronary Arteries.—ORIGIN. Their manner of origin is peculiar. They arise from the ascending aorta, opposite the upper margins of the aortic semilunar valves (fig. 254). Behind each valve the aorta shows a dilatation. These dilatations are the *sinuses of Valsalva.*

The *right coronary artery* arises from the anterior right sinus of Valsalva, and appears between the right auricular appendix and the pulmonary artery. It winds round in the right auriculo-ventricular groove, and, having reached the posterior surface of the heart, divides into two branches (fig. 250).

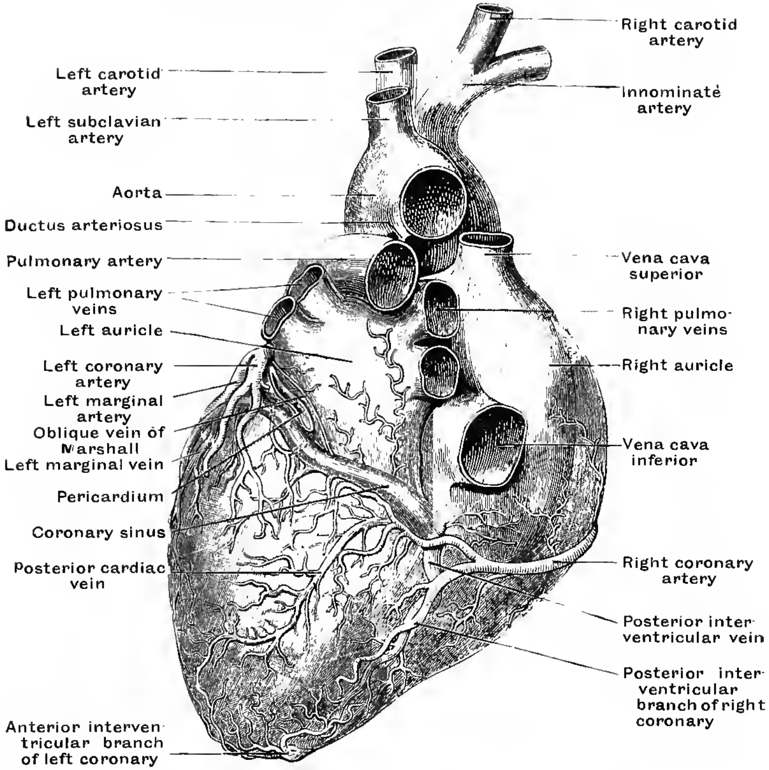
FIG. 249.—ANTERIOR VIEW OF THE HEART, SHOWING ITS ARTERIES AND VEINS. (*From Morris's 'Anatomy.'*)


Innominate
Left carotid
Left subclavian
Right pulmonary vein
Left pulmonary vein
Left auricular appendix
Right auricle
Left marginal artery
Right auricular appendix
Anterior interventricular branch of the great cardiac vein
Right coronary artery
Branch to anterior wall of right ventricle (preventricular)
Left coronary (interventricular) artery
Right marginal artery and vein (vein of Galen)
Commencing radicles of posterior interventricular vein

One is continued round the heart to anastomose with the left coronary artery, the other descends in the posterior interventricular groove towards the apex of the heart. The artery gives branches upwards to the auricle (auricular) and downwards to the ventricle, one of which (marginal) is of large size, and extends along the right margin of the ventricle towards the apex (fig. 249).

The *left coronary artery* arises from the anterior left sinus of Valsalva, and appears between the left auricular appendix and the pulmonary artery. It divides almost immediately into a descending and a transverse branch. The *descending* branch passes down to the apex in the anterior inter-ventricular groove. The *transverse* branch reaches the back of the heart in the auriculo-ventricular groove and anastomoses with the right coronary artery. Several branches pass upwards to the auricle, and downwards to the ventricle. One of these passes down to the apex along the margo obtusus (left marginal).

Fig. 250.—Posterior view of the heart, showing its arteries and veins. (*From Morris's 'Anatomy.'*)



Veins of the Heart.—The arrangement of the veins of the heart does not correspond with that of the arteries. Nearly all the veins empty their blood into the coronary sinus (figs. 250 and 253).

Coronary Sinus (fig. 253).—The coronary sinus lies at the back of the heart in the auriculo-ventricular groove between the left auricle and left ventricle. It is really an intrinsic part of the heart, being the left extremity of the sinus venosus, a chamber which received the right and left superior venæ cavæ (ducts of Cuvier) in the early fœtus. The right part of the sinus venosus, with the right superior vena cava, joins the right auricle and forms part of it, while the left superior vena cava almost disappears, and the left end or horn of the sinus venosus is reduced to the coronary sinus and receives the cardiac veins.

Its opening into the right auricle is narrow (fig. 252, 10), and will be seen within that chamber situated between the opening of the inferior vena cava and the auriculo-ventricular orifice. A fold of endocardium, the valve of Thebesius, guards it.

The coronary sinus receives at its left extremity the anterior or great cardiac vein, and at its right extremity the right or small cardiac vein. Below it receives the posterior inter-ventricular vein, and above, near its left extremity, the oblique vein of Marshall, a remnant of the left superior vena cava (fig. 250).

Cardiac Veins.—(1) The *left*, *anterior* or *great cardiac vein* commences as the anterior inter-ventricular vein near the apex of the heart. Having reached the auriculo-ventricular groove, it winds round the heart to reach the left extremity of the coronary sinus.

TRIBUTARIES.—In addition to veins from the anterior surfaces of both ventricles, it receives *posterior cardiac* veins from the posterior surface of the left ventricle.

(2) The *right* or *small cardiac vein* commences on the front of the heart, and runs in the auriculo-ventricular groove between the right auricle and the right ventricle to enter the right extremity of the coronary sinus. It receives a number of *anterior cardiac* veins from the surface of the right auricle and ventricle.

(3) The *posterior inter-ventricular vein* ends in the coronary sinus. It commences behind the apex.

(4) The *oblique vein of Marshall* (fig. 247) passes across the back of the left auricle to open into the coronary sinus. This vein is a vestige of the embryonic left superior vena cava (duct of Cuvier). Notice that it can be traced to the vestigial

fold of Marshall on the serous layer of the pericardium. Sometimes it may be followed through the pericardium to the left superior intercostal vein. With the exception of the oblique vein of Marshall, the orifices of all the veins which open into the coronary sinus are guarded by valves (fig. 253).

(5) A few small veins from the heart-wall, *venæ minimæ cordis*, open directly into the right auricle, their small orifices forming the foramina Thebesii.

Nerve Supply of the Heart (see fig. 251).—The heart is elaborately supplied with nerves, which come from two sources on each side of the body, the vagus and the sympathetic of the cervical and upper dorsal regions. The nature of the vagal fibres the student already knows to be inhibitory and depressory; the sympathetic, acceleratory.

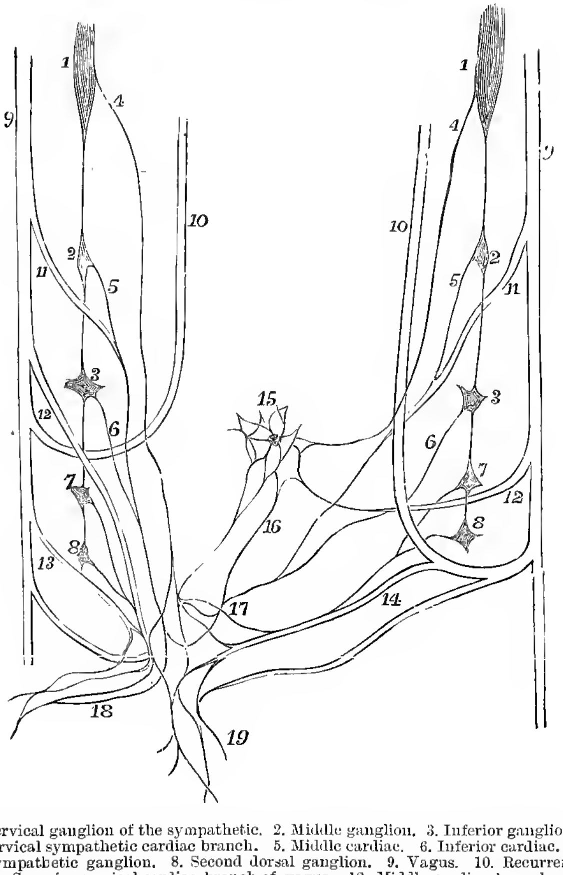
Cardiac Plexuses.—The cardiac nerves derived from these sources form two *cardiac plexuses*: the *superficial*, on and below the arch of the aorta; the *deep*, behind the arch of the aorta and on the bifurcation of the trachea. From these two plexuses, branches stream down; some join the right coronary artery, and on it pass to form the *right coronary plexus*; some join the left artery and form the *left coronary plexus*. The nerve fibres of the coronary plexuses end in a network within the walls of the heart.

(1) Vagal Branches.—Four branches arise on each side (fig. 251), three in the cervical stage and one in the superior mediastinal stage of the vagus. The upper cervical branches join with sympathetic twigs, and as a rule are hard to define. The inferior of the three *left* cervical branches crosses the arch of the aorta and ends in the superficial cardiac plexus. The remaining five cervical branches of the vagus end in the deep plexus.

(2) Sympathetic Branches.—There are three on each side, one springing from each of the cervical sympathetic ganglia, besides minor branches from the upper two dorsal ganglia. The superior of the *left* side passes across the arch of the aorta to the superficial cardiac plexus, which is thus formed by a vagal and a sympathetic twig. The remaining branches end in the deep plexus. They join with the vagal branches in the neck, forming a plexus-like arrangement as they descend.

The cardiac fibres from the cervical ganglia emerge really by the white rami communicantes of the first three or four dorsal nerves, and reach the sympathetic cord, in which they ascend. The cardiac branches from the chain of ganglia correspond to the splanchnic nerves of the thorax and abdomen. They arise in the neck because the heart is developed there.

FIG. 251.—SCHEME OF THE FORMATION OF THE DEEP AND SUPERFICIAL CARDIAC PLEXUSES. (*Clark.*)



1. Superior cervical ganglion of the sympathetic. 2. Middle ganglion. 3. Inferior ganglion. 4. Superior cervical sympathetic cardiac branch. 5. Middle cardiac. 6. Inferior cardiac. 7. First dorsal sympathetic ganglion. 8. Second dorsal ganglion. 9. Vagus. 10. Recurrent laryngeal. 11. Superior cervical cardiac branch of vagus. 12. Middle cardiac branch of vagus. 13. Inferior cardiac branches of vagus. 14. Cardiac branches of left recurrent nerve. 15. Superficial cardiac plexus and ganglion. 16. Communicating branches between deep and superficial plexus. 17. Deep cardiac plexus. 18. Right and, 19. Left coronary plexuses.

The *right coronary plexus* is formed mostly from the superficial *cardiac* plexus, but a considerable addition comes from the deep cardiac plexus.

The *left coronary plexus* is formed by branches of the deep cardiac plexus. They pierce the pericardium to reach the commencement of the left coronary artery.

The *deep cardiac plexus* communicates freely with, and is not easily separated from, the anterior pulmonary plexus. The plexus is surrounded by peribronchial tissue and glands.

The *superficial cardiac plexus* is situated on and below the arch of the aorta, and commonly contains a small ganglion—the ganglion of Wrisberg.

Lymphatic System of the Heart.—The lymphatics form a rich plexus beneath the visceral pericardium. The efferent trunks ascend on the pulmonary artery and end in the glands of the superior mediastinum.

Interior of the Heart.—The interior of each of the four chambers of the heart is now to be examined.

The **Right Auricle** and its appendix were opened by two incisions enclosing in a triangular flap the greater part of its anterior wall. The following points should be noted in it (see fig. 252):

(1) The greater part of the cavity of the right auricle is smooth, but in the appendix and on the anterior wall a number of parallel muscular ridges are seen. These are the *musculi pectinati,* which extend from the appendix on the anterior wall to terminate at a vertical ridge, the *crista terminalis.*

(2) This ridge corresponds to a slight groove (the sulcus terminalis) on the anterior surface of the auricle, passing between the terminations of the venæ cavæ. The ridge and groove indicate the line of demarcation between the two parts out of which the right auricle is developed. The venæ cavæ and coronary sinus open into the part derived from the sinus venosus; the rest is developed out of the primitive auricle.

(3) From the thinness of the auricular wall, it can be seen it is not of much power as a pump. It feeds the right ventricle and acts as a reservoir during systole.

(4) On the posterior wall, which is formed by the inter-auricular septum, is an oval depression where the septum is very thin. This is the *fossa ovalis* (fig. 252 8^1), representing the foramen ovale of the fœtus. A slight oblique perforation sometimes persists at the upper part of the fossa. Around the upper and lateral parts of this fossa, the septal wall is raised to form the *annulus ovalis* (7); below, where the annulus is deficient, the

floor of the fossa is continued uninterruptedly into the wall of the inferior vena cava. An elevation below the opening of the superior vena cava is named the *tubercle of Lower*.

(5) The *superior vena cava* opens at the upper part of the cavity; its orifice is directed downwards and forwards towards the auriculo-ventricular opening, and is not guarded by a valve. When the auricle contracts there is no structure to prevent regurgitation of blood into the vena cava. The nearest valves are those of the jugular and subclavian veins.

(6) The *inferior vena cava* opens at the lower and posterior angle of the cavity. It is directed towards the fossa ovalis. In the fœtus the stream of blood from the inferior cava passes upwards and backwards to the foramen ovale, behind the down-flowing stream from the superior cava to the right ventricle.

(7) In front of the inferior vena cava, and extending to the anterior margin of the annulus ovalis, is a thin membranous fold which varies considerably in size and is frequently perforated. This is the remains of the *Eustachian valve* (8), which directed the blood in the fœtus from the inferior vena cava to the foramen ovale.

(8) The *auriculo-ventricular orifice* lies at the lower and anterior part of the cavity. The orifice is large enough to take three fingers easily. In disease of the heart it may become contracted and cause obstruction.

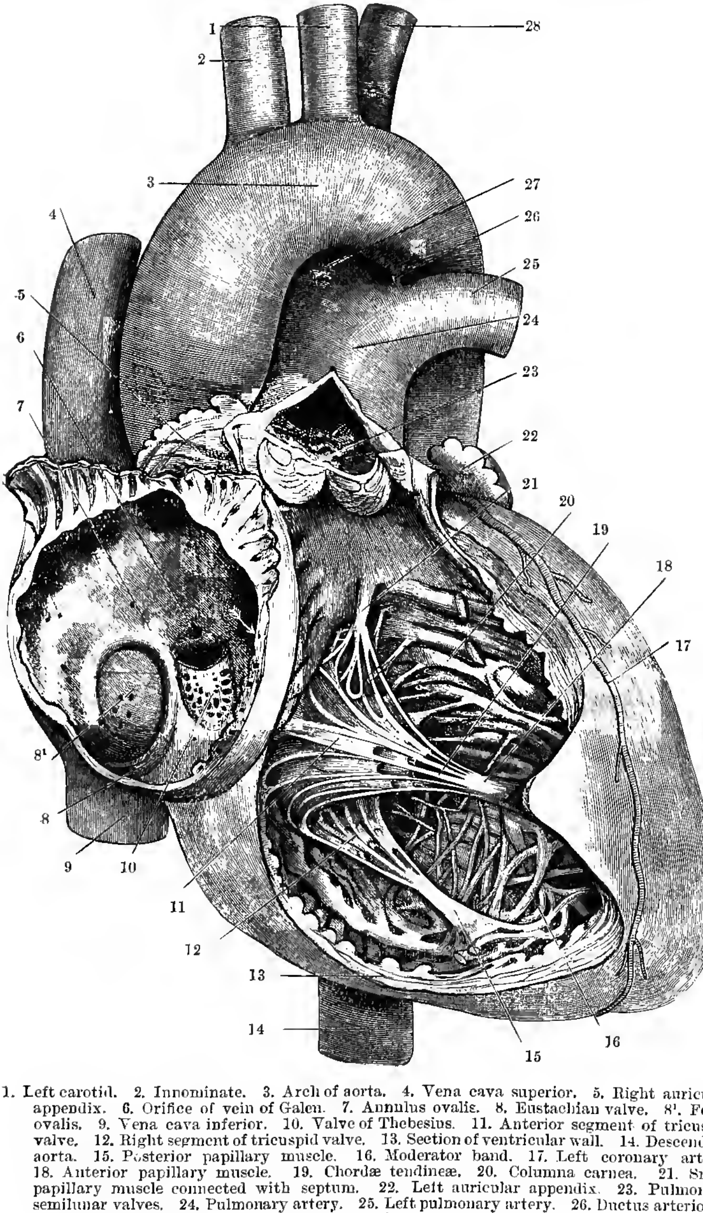
(9) The *coronary sinus* enters at the interval between the Eustachian valve and the auriculo-ventricular opening. It is guarded by a thin imperfect fold, the *valve of Thebesius* or *coronary valve* (10).

(10) The foramina of Thebesius are scattered irregularly on the auricular wall; they receive the small veins of the heart, the venæ minimæ cordis.

The Right Ventricle (see fig. 252).—By two incisions the anterior wall of the right ventricle has been already thrown open as a triangular flap. The following points are to be noted in this cavity:

(1) MARKINGS.—Excepting in the infundibulum (conus arteriosus), where the ventricular wall is smooth, the cavity presents an irregular network of fleshy ridges on its walls, called collectively the *columnæ carneæ*. They represent the remains of a sponge-work which originally nearly filled the fœtal ven-

Fig. 252.—Anterior view of the right chambers of the heart, with the great vessels. (*From Morris's 'Anatomy.'*)



1. Left carotid. 2. Innominate. 3. Arch of aorta. 4. Vena cava superior. 5. Right auricular appendix. 6. Orifice of vein of Galen. 7. Annulus ovalis. 8. Eustachian valve. 8^1. Fossa ovalis. 9. Vena cava inferior. 10. Valve of Thebesius. 11. Anterior segment of tricuspid valve. 12. Right segment of tricuspid valve. 13. Section of ventricular wall. 14. Descending aorta. 15. Posterior papillary muscle. 16. Moderator band. 17. Left coronary artery. 18. Anterior papillary muscle. 19. Chordæ tendineæ. 20. Columna carnea. 21. Small papillary muscle connected with septum. 22. Left auricular appendix. 23. Pulmonary semilunar valves. 24. Pulmonary artery. 25. Left pulmonary artery. 26. Ductus arteriosus. 27. Right pulmonary artery. 28. Left subclavian.

tricular cavity. The sponge-work persists in several forms: (*a*) *Columnæ carneæ* (20) are mere elongated ridges on the ventricular wall. (*b*) The *trabeculæ carneæ* are attached at each extremity, but free in the middle. (*c*) The *musculi papillares* (15) are fleshy projections arranged in two groups, anterior and posterior, attached by their bases to the ventricular wall, and at their apices by small fibrous cords (*chordæ tendineæ*) to the auriculo-ventricular valve. (*d*) A fourth representative of the sponge-work is often met with in the form of a fleshy band, the *moderator band* (16). It stretches across the cavity from the septal to the anterior wall near the anterior papillary muscles. This may help to resist over-distension of the ventricle.

(2) The *auriculo-ventricular orifice* is surrounded by a fibrous ring and guarded by the auriculo-ventricular or tricuspid valve (fig. 257).

(3) The *tricuspid valve* is a tubular or funnel-shaped membranous fold of endocardium, attached above to the fibrous ring around the orifice; from which it receives some strengthening fibres (fig. 252). Below, where it hangs into the ventricular cavity, it is notched, so as to form three main segments or cusps. Smaller cusps are found in the intervals between the main cusps. Of the three main cusps, one is *anterior* and lies between the auriculo-ventricular orifice and the infundibulum (fig. 252). A second is *posterior* and lies against the inter-ventricular septum (septal cusp), and a third lies towards the *right* side.

(4) The *chordæ tendineæ* from the musculi papillares pass to the under surfaces and margins of the cusps, those of one musculus passing to two segments of the valve. Those from the anterior papillary muscle pass to the interval between the anterior and right cusps, those from the posterior papillary muscle reaching the interval between the right and septal cusps. A considerable number of chordæ tendineæ are attached *directly* to the septum without any musculi papillares. These pass mainly to the septal cusp, a few reaching the interval between the septal and anterior cusps.

(5) The *infundibulum* is the narrow smooth upper part of the ventricle leading to the pulmonary aorta. It is situated in front of the cardiac orifice of the ascending aorta.

(6) The *pulmonary orifice* lies at the upper part of the infundibulum, and is guarded by the *pulmonary or semilunar valve*,

which consists of three thin, membranous segments (fig. 252). Of these one is anterior and two postero-lateral. Each segment is semilunar or semicircular in shape, and is attached by its convex border to the wall of the pulmonary aorta. The free border is directed away from the heart, and at its middle is thickened to form a small nodule, the *corpus Arantii.* On each side of the nodule the marginal portion of the valve is very thin and forms the *lunule* (fig. 254). When the segments of the valve are closed, the corpora Arantii meet in the middle of the lumen of the arterial orifice, any chinks which might be left between the lunulæ of the segments being thus completely closed up. Behind each segment the wall of the pulmonary aorta shows a recess, the *sinus of Valsalva.* The sinuses of Valsalva ensure that regurgitating blood will pass behind the valves and effectually close them. The semilunar valves, like the auriculo-ventricular, are formed of folds of endocardium enclosing fibrous tissue. The fibrous tissue for the most part radiates from the nodule towards the fixed border, but the lunule is devoid of fibres and formed merely of endocardium. The valves are delicate in structure, and easily destroyed by disease. In rheumatic fever they may become inflamed. Inflammation is followed by contraction and adhesion. They are no longer competent as valves and may offer obstruction to the flow of the blood.

The Left Auricle (fig. 253).—To examine this chamber the apex of the heart should be tilted upwards, and towards the right, and the left auricle opened by an incision passing across between the right and left pulmonary veins, and extending into the appendix. The cavity of the left auricle forms an elongated transverse chamber between the right and left pulmonary veins. The following points are noted in its interior:

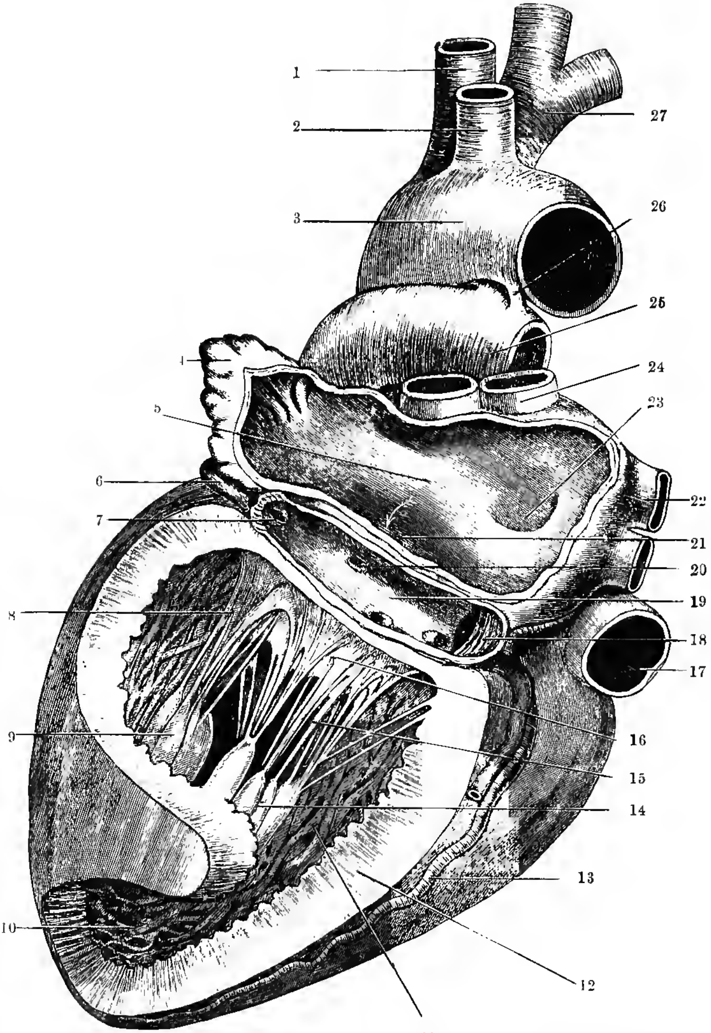
(1) Its walls are smooth, excepting in the appendix, where musculi pectinati are well marked.

(2) On the auricular septum the upper margin of the septum ovale is seen. It is bounded by an incomplete annulus, which is deficient above (23).

(3) On the posterior wall are the openings of the pulmonary veins, usually two on each side. These are devoid of valves.

(4) In the lower part of the cavity is the auriculo-ventricular opening, which is rather smaller than the right auriculo-ventricular orifice.

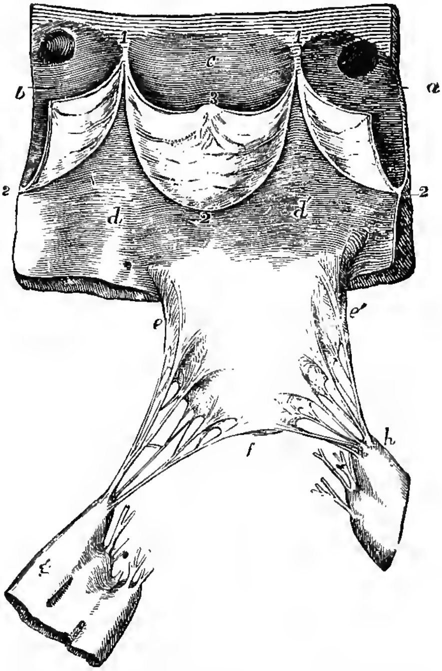
FIG. 253.—POSTERIOR VIEW OF THE LEFT CHAMBERS OF THE HEART, WITH THE CORONARY SINUS LAID OPEN. (*From Morris's 'Anatomy.'*)



1. Left carotid. 2. Left subclavian. 3. Aorta. 4. Left auricular appendix. 5. Interior of left auricle. 6. Great cardiac vein. 7. Valves of great cardiac vein. 8. Anterior segment of mitral valve. 9. Compound anterior papillary muscle. 10. Fine meshwork of columnæ carneæ at apex of ventricle. 11. Columnæ carneæ. 12. Section through wall of left ventricle. 13. Coronary artery. 14. Compound posterior papillary muscles. 15. Chordæ tendineæ. 16. Posterior segment of mitral valve. 17. Vena cava inferior. 18. Valve of Thebesius. 19. Coronary sinus. 20. Valved orifice of vein in coronary sinus. 21. Left auriculo-ventricular opening. 22. Right pulmonary veins. 23. Concave edge of the valve of the foramen ovale. 24. Left pulmonary veins. 25. Commencement of left pulmonary artery. 26. Ductus arteriosus. 27. Innominate.

The Left Ventricle (fig. 253).—This cavity is laid open by removing its lateral wall. This is done by three incisions enclosing the lateral or left wall in a triangle. The base of the triangle lies below the auriculo-ventricular groove; the anterior and posterior incisions, which meet at the apex, pass down on the left side of the inter-ventricular grooves. Only points of difference between the left and right ventricles need be mentioned.

FIG. 254.—PORTION OF THE WALL OF THE VENTRICLE, *d*, *d'*, AND AORTA, *a*, *b*, *c*, SHOWING ATTACHMENTS OF ONE FLAP OF THE MITRAL AND THE AORTIC VALVES. (*Allen Thomson.*)



h and *g*. Musculi papillares. *e*, *e'*, *f*. Attachment of the chordæ tendineæ.

(1) The wall of the left ventricle is two or three times thicker than that of the right, because its work is so much greater (fig. 255).

(2) The cavity is more elongated and narrower on the left side. It reaches to the apex of the heart.

(3) Owing to the inter-ventricular septum (septal wall) bulging towards the right side, the cavity of the left ventricle is circular on transverse section, that of the right being crescentic (fig. 255).

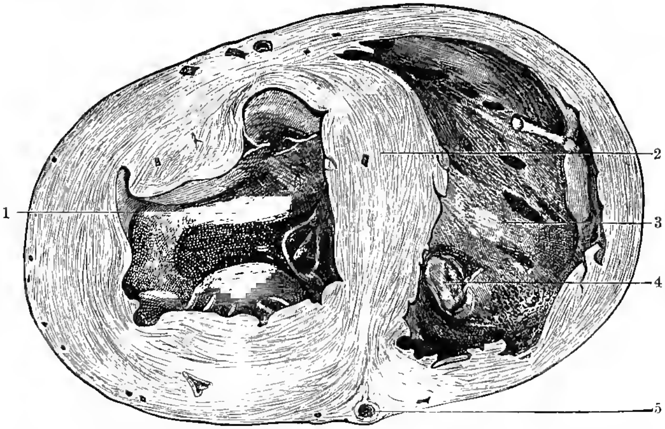
(4) The columnæ carneæ are better marked on the left side, and the musculi papillares and chordæ tendineæ are much stronger. The columnæ carneæ are best marked near the apex, the upper part of the anterior wall and septum being smooth.

(5) The segments of the left auriculo-ventricular valve (*mitral* or *bicuspid*) are much thicker. They are two in number, and placed one in front of the other. The valve and its two segments form a membranous funnel projecting within the cavity of the ventricle (fig. 253).

(6) The semilunar segments of the aortic valve are also stronger, and the corpora Arantii thicker. The sinuses of Valsalva are larger, giving rise to a distinct bulging of the aortic wall opposite each segment. The segments are placed two in front, right and left, and one behind. The coronary arteries arise from the right and left sinuses of Valsalva (fig. 254).

(7) The smooth portion of the ventricle immediately below the aortic valves is known as the *aortic vestibule.*

FIG. 255.—TRANSVERSE SECTION THROUGH THE HEART NEAR ITS APEX, SHOWING THE RELATIVE THICKNESS OF ITS MUSCULAR WALLS, THE BULGING OF THE SEPTUM TOWARDS THE RIGHT VENTRICLE, AND THE SHAPE OF THE CAVITIES. (*From Morris's 'Anatomy.'*)



1. Cavity of left ventricle. 2. Septum. 3. Cavity of right ventricle. 4. Section of papillary muscle. 5. Posterior coronary artery.

The auriculo-ventricular and semilunar valves of the left side of the heart are especially liable to disease.

Septum of the Heart.—A septum divides the heart into a right and left half. It is composed of four parts or minor septa (fig. 256) :

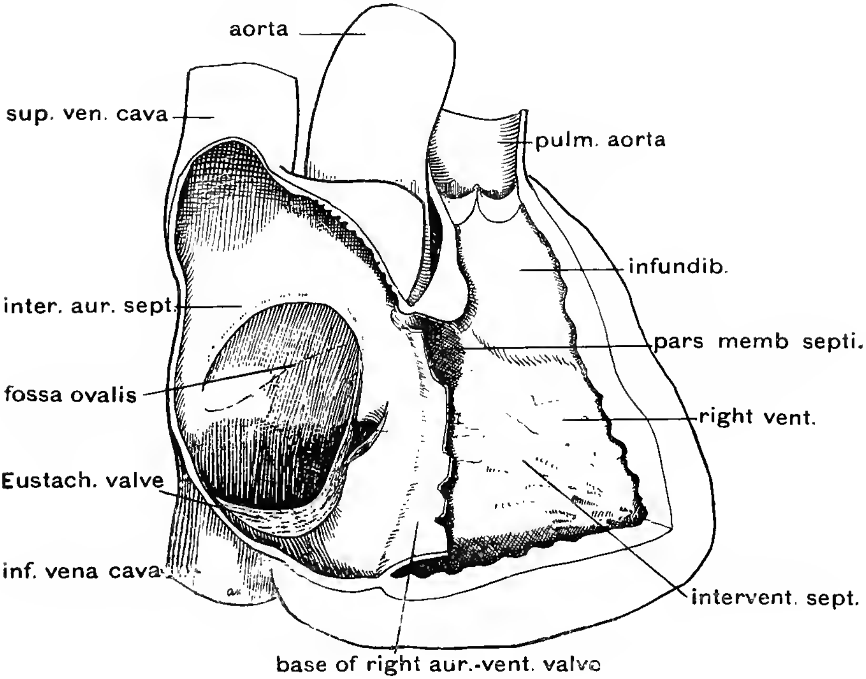
(1) The *inter-auricular septum,* completed by the septum ovale in the adult, and perforated in the fœtus by the foramen ovale.

(2) A *small intermediate* part separating the two auriculo-ventricular orifices. It gives attachment to the septal parts of the auriculo-ventricular valves.

(3) The *aortic septum,* separating the aortic vestibule from the infundibulum of the right ventricle.

(4) The *inter-ventricular septum* is for the most part thick and fleshy, but at its upper part it is thin and translucent, and formed of two closely applied layers of endocardium, without any intervening muscular fibres. This is the *pars membranacea*, which is developed later than, and in a manner different from, the other parts of the septum. It is the point at which the three septa named last meet. A congenital deficiency is sometimes met with in the pars membranacea, thus maintaining permanently a communication between the two ventricles.

FIG. 256.—DIAGRAM OF THE SEPTA OF THE HEART.



The Pulmonary Aorta (fig. 252).—The *pulmonary aorta or artery*, about two inches in length, commences in the infundibulum of the right ventricle, and lies at first in front of the ascending aorta. It then inclines to the left side of the aorta, and divides into its right and left branches.

Its course is nearly horizontal from front to back. The coronary arteries and auricular appendices lie at each side of it.

It lies completely within the pericardium, and is enclosed in the same sheath of visceral pericardium as the ascending aorta. The transverse sinus of the pericardium passes behind the two aortæ.

The *right pulmonary artery* pierces the fibrous pericardium and passes behind the aorta and superior vena cava to reach the root of the right lung, where it divides into two branches. The lower supplies the middle and lower lobes of the right lung (fig. 241).

The *left pulmonary artery* passes outwards in front of the descending aorta to reach the root of the left lung, where it divides into two branches to supply the upper and lower lobes of the left lung. It passes in front of and above the left bronchus. From its commencement a fibrous cord extends to the arch of the aorta. This is the remains of the *ductus arteriosus*, which conveyed the blood in the fœtus from the pulmonary artery to the aorta (fig. 246).

The *pulmonary veins* are two in number on each side. Each pair opens close together into the left auricle. The veins lie in front of and below the arteries (fig. 241).

Position of the Valves of the Heart on the Surface of the Thorax (see fig. 245, p. 261).—The auriculo-ventricular orifices are situated obliquely behind the sternum. They lie in the line of the auriculo-ventricular groove, from the insertion of the third left to the insertion of the fifth right cartilage (fig. 245). The right is the lower and more anterior, and to the right of the left orifice.

The *aortic orifice* is behind and to the right of the pulmonary. Its position is behind the sternum, near the insertion of the third left cartilage. The *pulmonary valve* is behind the inner end of this cartilage.

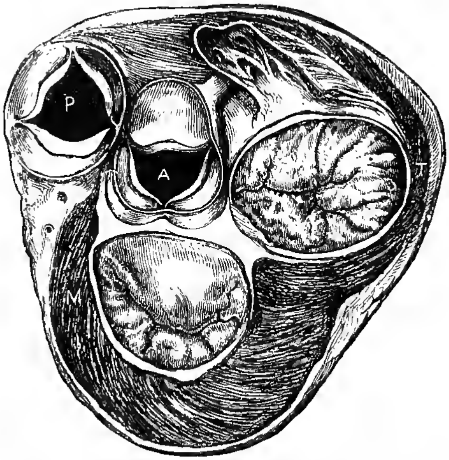
The blood of the ascending aorta conveys the sound of the aortic valve to the surface of the chest at the insertion of the second right costal cartilage. The left auriculo-ventricular valve is heard best at the apex.

Some Points in the Structure of the Heart.—The heart is now to be removed from the interior of the pericardium, leaving the pulmonary and ascending aortæ in position. They are divided above the semilunar valves. The venæ cavæ and pulmonary veins are divided as they join the heart. Very little can be made out of the arrangement of the muscular fibres. To see them the heart of an ox or sheep must be parboiled. But the following points can be made out :

(1) The auricular muscular fibres form a thin layer. The fibres encircle the venous openings and act partly as sphincters. The coronary sinus is covered by cardiac muscle fibres and also contracts.

(2) A section such as is shown in fig. 257 should be made. It will be seen that the orifice of the pulmonary aorta is situate rather apart, but the aortic and the right and left auriculo-ventricular are close together, separated only by a triangular body. This body contains fibrous tissue, continuous with the fibrous rings surrounding the openings into the ventricles. The substance of these rings is continuous with the tissue of the auriculo-ventricular valves. The size of the openings depends in part on the tone of the cardiac muscle which surrounds the rings. To these fibrous rings the muscular fibres of the auricles and ventricles are also attached.

Fig. 257.—A section of the heart at the level of the auriculo-ventricular valves, seen from above. (*Sibson.*)



P. Pulmonary artery. A. Aorta. M. Mitral valve. T. Tricuspid valve.

THE AORTA

In the thorax the **aorta** consists of three portions :

(1) Ascending aorta. (2) Arch of the aorta.
(3) Descending aorta.

Ascending Aorta.—The ascending aorta lies within the pericardium (fig. 248). It commences in the aortic vestibule of the left ventricle, behind the sternum, opposite the inner end of the third left costal cartilage. It extends upwards, forwards, and towards the right until it reaches the second right costal cartilage, where it bends backwards as the aortic arch. At its commencement it has three slight dilatations, corresponding to the sinuses of Valsalva, and along its right side it is somewhat dilated, forming the *great sinus of the aorta*.

RELATIONS.—The ascending aorta is enclosed with the pulmonary within a sheath of visceral pericardium. The sinus transversus separates it from the left auricle. In front of it is the right auricular appendix and pulmonary artery which afterwards passes to its left side. The right pulmonary artery lies behind it, and the superior vena cava descends on its right side to reach the right auricle.

BRANCHES.—The right and left *coronary arteries* arise from the right and left sinuses of Valsalva.

Arch of the Aorta (fig. 230, p. 226, and fig. 258).—The arch commences as the aorta emerges from the pericardium opposite the second right costal cartilage, and lies in the superior mediastinum. It extends backwards and towards the left, over the root of the left lung, to reach the left side of the body of the fourth dorsal vertebra and the disc below it, where it becomes the descending aorta.

RELATIONS.—These are of especial importance, as this vessel is liable to be the seat of aneurisms, which press on the surrounding structures and thus give rise to numerous symptoms.

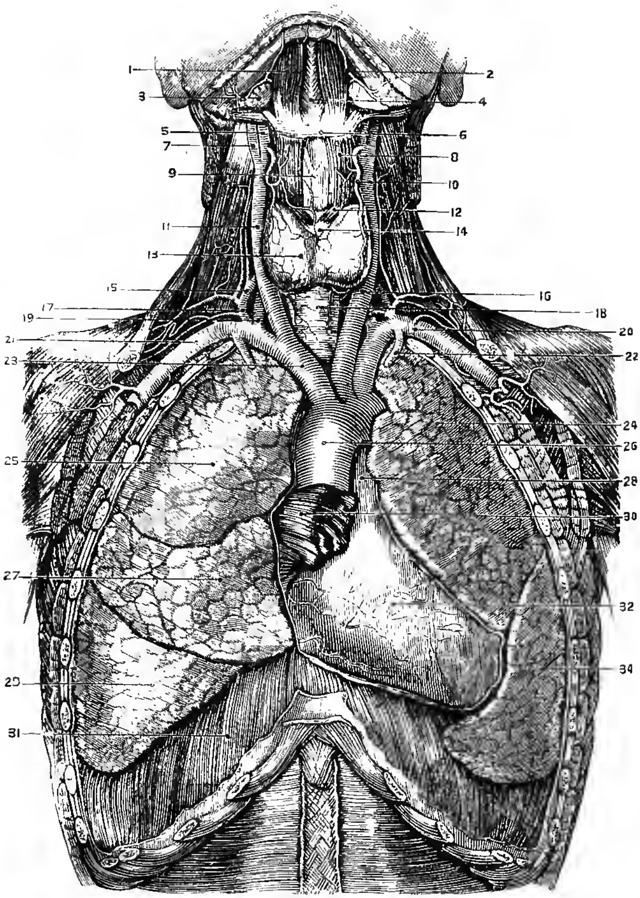
(1) The *anterior or left surface* is covered superficially and on its left side by the left pleura, and is crossed successively by the left phrenic nerve, the inferior cardiac branch of the left pneumogastric nerve, the left superior cervical cardiac branch of the sympathetic, the pneumogastric nerve, and near its termination by the superior intercostal vein.

(2) Its *posterior or right surface.* The right pleura covers it at first. It lies against the trachea (fig. 260), œsophagus, and thoracic duct, the deep cardiac plexus and the numerous bronchial glands. The left recurrent laryngeal nerve passes up behind it.

(3) *Below.* The concavity of the arch is in relation to the

bifurcation of the pulmonary aorta, to the left branch of which it is joined by the ligament of the ductus arteriosus. Internal

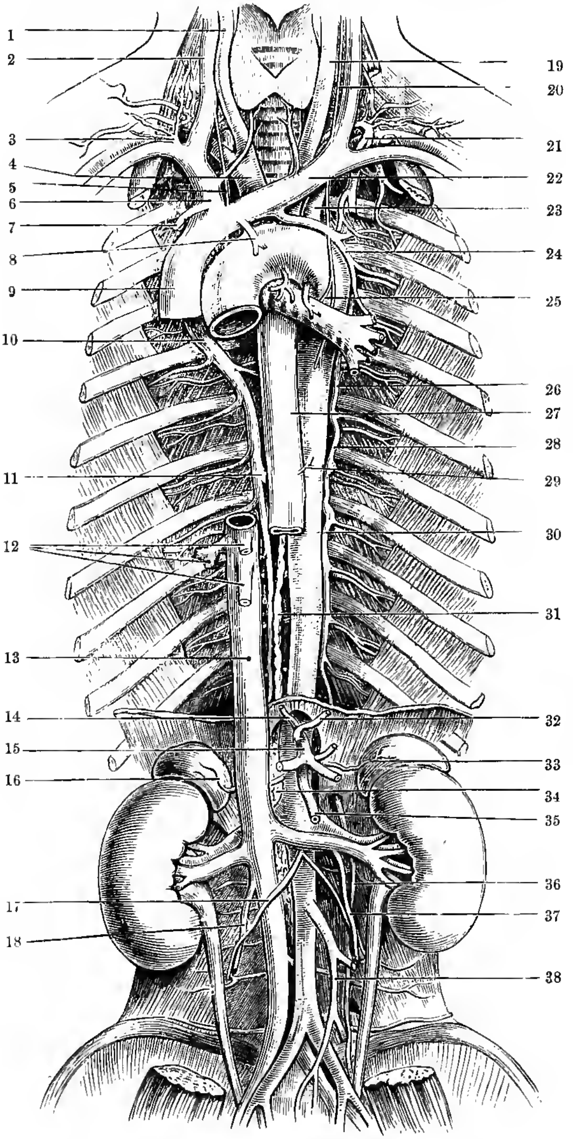
FIG. 258.—THE HEART AND LARGE ARTERIES OF THE THORAX AND NECK. (*Bonamy and Beau.*)



1. Digastric. 2. Submental artery (facial). 3. Submaxillary gland. 4. Mylo-hyoid. 5. External carotid. 6. Hyoid bone. 7. Internal carotid. 8. Thyro-hyoid. 9. Thyroid cartilage. 10. Superior thyroid artery. 11. Right common carotid. 12. Crico-thyroid. 13. Thyroid body. 14. Cricoid cartilage. 15. Inferior thyroid artery. 16. Left common carotid. 17. Thyroid axis. 18. Trachea. 19. Vertebral artery. 20. Left subclavian artery. 21. Right subclavian artery. 22. Internal mammary artery. 23. Innominate artery arising from horizontal aorta. 24. Left lung (upper lobe). 25. Right lung (upper lobe). 26. Ascending aorta. 27. Right lung (middle lobe). 28. Pulmonary artery. 29. Right lung (lower lobe). 30. Right auricle. 31. Diaphragm. 32. Front of right ventricle. 34. Left lung (lower lobe).

to the ductus arteriosus, lymphatic glands and the superficial cardiac plexus are situated, and on the outer side of the

FIG. 259.—THE SUPERIOR AND INFERIOR VENÆ CAVÆ, THE INNOMINATE VEINS, AND AZYGOS VEINS. (*From Morris's 'Anatomy.'*)



1. Right common carotid artery. 2. Right internal jugular vein. 3. Right lymphatic duct. 4. Innominate artery. 5. Right pneumogastric nerve. 6. Right innominate vein. 7. Internal mammary vein. 8. Trunk of the pericardiac and thymic veins. 9. Vena cava superior. 10. Vena azygos major. 11. Vena azygos minor (inferior), crossing spine to enter vena azygos major. 12. Hepatic veins. 13. Vena cava inferior. 14. Right phrenic artery. 15. Cœliac axis. 16. Right middle suprarenal artery. 17. Right spermatic artery. 18. Right spermatic

obliterated duct the left recurrent laryngeal nerve winds underneath the arch of the aorta. The left bronchus passes outwards below it (fig. 259).

(4) *Superiorly* the left innominate vein crosses over the roots of the branches given off from the convexity of the arch (fig. 259). An aneurism of the arch may open into the trachea, left bronchus, pleural cavities or œsophagus.

BRANCHES.—These are usually three in number, viz. innominate, left carotid, and left subclavian (fig. 258). Occasionally the left carotid arises with the innominate. The right subclavian may arise from the aorta beyond the left subclavian. A vertebral artery or a thyroid artery occasionally arises direct from the arch. These branches will be considered later.

Descending Aorta (fig. 259).—The descending aorta lies in the posterior mediastinum, and extends from the left side of the lower border of the fourth dorsal vertebra to the aortic opening in the diaphragm opposite the twelfth dorsal vertebra. There it becomes the abdominal aorta. At first the artery lies on the left of the vertebral line, but it inclines gradually inwards and gains the middle line before it pierces the diaphragm. Branches from the upper four dorsal ganglia of the sympathetic end on the aorta and form the *thoracic aortic plexus.* Excruciating pains, felt through these in aneurism of the aorta, are referred along the nerves of the arm.

RELATIONS.—Three stages may be recognised in its course from its *anterior* relationships :

First. Behind the root of the left lung (opposite the fifth dorsal vertebra and disc).

Second. Behind the pericardium (opposite the sixth, seventh, eighth, and part of the ninth vertebræ, fig. 262).

Third. Behind the diaphragm (opposite the tenth and eleventh vertebræ, fig. 238, p. 243).

The *œsophagus* lies to the right of its first stage ; in front of the second stage ; in the third stage it passes towards the left and leaves the aorta opposite the tenth vertebra. *Posteriorly* the aorta rests on the anterior common ligament, the borders of the vertebræ, and the left azygos veins.

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vein. 19. Left common carotid artery. 20. Left pneumogastric nerve. 21. Thoracic duct. 22. Left innominate vein. 23. Left subclavian artery. 24. Left superior intercostal vein. 25. Recurrent laryngeal nerve. 26. Vena azygos minor (superior). 27. Œsophagus. 28. Left upper azygos vein. 29. Œsophageal branches from aorta. 30. Vena azygos minor. 31. Thoracic duct. 32. Left phrenic artery. 33. Left middle suprarenal artery. 34. Receptaculum chyli. 35. Superior mesenteric artery. 36. Left ascending lumbar vein. 37. Left spermatic vessels. 38. Inferior mesenteric artery.

On its *left* side it is covered by the pleura, and to its *right* side are the œsophagus, thoracic duct, and vena azygos major. The right pleura covers the right aspect in its third stage.

BRANCHES.—In addition to the *bronchial* and *intercostal* arteries which have been considered (see p. 227), the descending aorta gives off *mediastinal*, *pericardiac*, and *œsophageal* branches. The œsophageal branches anastomose with the œsophageal branches of the gastric and inferior thyroid arteries.

Branches of the Aortic Arch (figs. 258, 259).—Three great vessels are given off by the aortic arch, viz. the innominate, left common carotid, and left subclavian arteries.

Innominate Artery.—COURSE. The innominate artery lies in the superior mediastinum. It extends upwards and to the right behind the manubrium sterni, and terminates behind the right sterno-clavicular articulation by dividing into the right common carotid and right subclavian arteries.

RELATIONS.—(1) The sternum, sterno-hyoid, and sterno-thyroid muscles, with the left innominate vein, lie *in front* of it.

(2) On its *right side* are the right innominate vein and right pleura, and pneumogastric nerve.

(3) At first it *lies on* the trachea, but higher up it passes to its right side. Usually the artery gives off no lateral branch; occasionally the *thyroidea ima* artery arises from it to end in the thyroid gland.

Left Common Carotid Artery (fig. 259).—Part lies in the superior mediastinum (thoracic stage) and part in the neck. The thoracic portion of the left common carotid artery ascends behind the manubrium sterni and the left sterno-clavicular articulation. It is clothed on its *left* side and in front by the left pleura; the left innominate vein crosses obliquely in front of it. *Behind*, it rests on the trachea, œsophagus, and thoracic duct; the left pneumogastric nerve descends on its left side. It ascends in front of and to the right of the next artery.

Left Subclavian Artery.—Like the last, it lies at first in the superior mediastinum. The mediastinal or thoracic portion of the left subclavian artery lies deeply in the upper part of the thorax, and takes a curved course on the pleural dome of the right lung to reach its *cervical stage* behind the left sterno-clavicular joint.

RELATIONS.—The left innominate vein and pneumogastric nerve lie in front of it; the trachea lies to its inner side.

Behind it are the left margin of the œsophagus and the thoracic duct. The left pleura covers its left aspect.

TRACHEA AND BRONCHI

The **trachea** (fig. 260) is about 4½ inches in length and extends from the lower border of the sixth cervical vertebra to the lower border of the fourth dorsal vertebra, where it divides into the two bronchi. It lies in the middle line and rests on the œsophagus in its entire course. It is easily separated from the œsophagus, only a few loose fibrous bands joining them.

The trachea is divided into two stages, the cervical and thoracic. The cervical stage is about 2½ inches long; the thoracic about 2 inches. The *cervical stage* is accessible to the surgeon; by extension of the neck, an inch of the thoracic stage becomes cervical. The trachea is elastic and can be stretched. It is attached above to the movable larynx; its attachment by the bronchi to the roots of the lungs is firm. The *thoracic stage* of the trachea lies in the superior mediastinum.

To expose the trachea in the superior mediastinum the following structures have to be removed: (1) The innominate veins and superior vena cava; (2) the arch of the aorta and its three trunks and superficial cardiac plexus; (3) the pericardium and pulmonary vessels; (4) the deep cardiac plexus and the great group of bronchial glands.

Relations.—(1) *Thoracic Stage.*—*In front* of it are (see fig. 222, p. 214) the manubrium sterni, origins of the sterno-hyoid and sterno-thyroid muscles, the left innominate vein and some remains of the thymus gland, the arch of the aorta and origins of the innominate and left common carotid arteries, together with the deep cardiac plexus (fig. 259).

The innominate artery, pleura and pneumogastric nerve lie in contact with the trachea on the *right* side; the left common carotid and left subclavian arteries and the recurrent laryngeal nerve on the *left* side. A group of bronchial glands lies in its bifurcation.

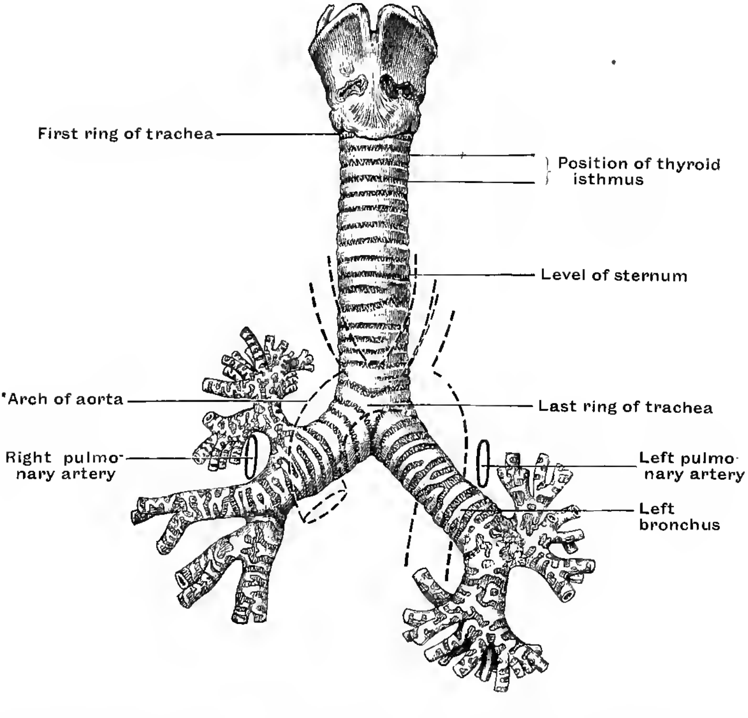
(2) *Cervical Stage.*—The trachea lies between the two common carotid arteries, and is in contact with the tracheal surface of the lateral lobes of the thyroid body. The recurrent laryngeal nerves ascend in the angle between it and the

œsophagus. The inferior thyroid arteries ascend in close relation to its sides.

In the neck the isthmus of the thyroid body, the inferior thyroid veins, the sterno-hyoid and sterno-thyroid muscles, with two layers of deep cervical fascia, are superficial to the trachea.

The trachea is strengthened by about 16 to 20 incomplete cartilaginous rings. These are deficient behind where the trachea rests on the œsophagus. This deficiency allows the œsophagus to expand in swallowing. Several of the rings are irregular, being bifurcated at one end, and the lowest ring usually gives off below a beaked process which projects into the bifurcation of the trachea. A loose fibrous sheath surrounds the trachea. Lymphatic glands are imbedded in it at each side. The sheath is continuous with the cervical fascia above and the sheaths of the bronchi below.

Fig. 260.—Anterior view of the larynx, with the trachea and bronchi. (*From Morris's 'Anatomy.'*)



The deficiency between the ends of the cartilages is filled up by the non-striated tracheal muscle. On the outer aspect of the muscle many of the mucous glands which open in the trachea may be seen.

Within the cartilages and the tracheal muscle joining their tips are the mucous and submucous coats. The submucous coat has rich plexuses of lymphatics, nerves and vessels. The nerves come from the recurrent laryngeal and pulmonary plexuses; the tracheal arteries from the thyroid and œsophageal; the lymphatics pass to the para-tracheal glands.

The Bronchi (fig. 242, p. 251, and fig. 260).—The bronchi extend outwards and downwards from the bifurcation of the trachea to enter the root of the lung. The left bronchus is rather longer than the right, owing to the left lung being pushed further away from the middle line by the projecting heart. The right bronchus is rather larger than the left, owing to the greater size of the right lung. The vena azygos major arches forwards over the right bronchus, and the arch of the aorta passes backwards over the left. Each bronchus is crossed by the corresponding pulmonary artery, and divides immediately afterwards into a number of hyparterial bronchi. On the right side an *eparterial branch* is given off from the bronchus, before it is crossed by the pulmonary artery (fig. 260). This passes to the upper lobe of the right lung. The œsophagus passes behind the bifurcation of the trachea and commencement of the left bronchus.

The Posterior Mediastinum.—A section through the posterior mediastinum at the level of the eighth dorsal vertebra is shown in fig. 261. The contents of this space are seen to be:

(1) The descending aorta, projecting somewhat into the left pleural space.
(2) The œsophagus, to the right of the aorta and nearly in the middle line; on it rest the two vagi.
(3) The thoracic duct, behind and to the right of the œsophagus.
(4) The vena azygos major, to the right of the thoracic duct and lying against the right pleura.

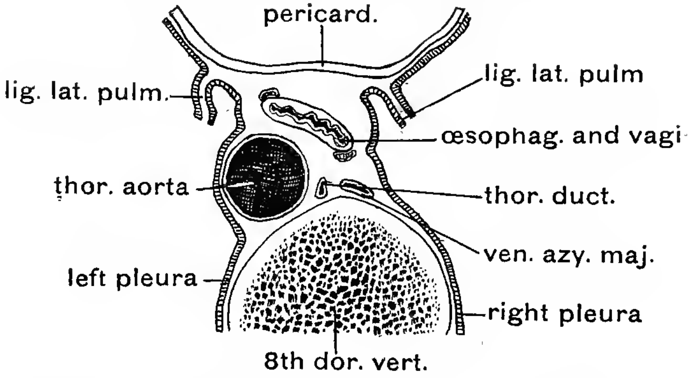
The fibrous pericardium and left auricle bound the posterior mediastinum in front at this level; the bodies of the vertebræ and anterior common ligament bound it behind.

The Œsophagus.—The œsophagus or gullet is nine or ten inches long, and extends from the lower border of the cricoid cartilage, opposite the sixth cervical vertebra, to the level of the tenth dorsal vertebra, where it pierces the diaphragm and enters the stomach.

STAGES IN ITS COURSE.—(1) *Cervical,* behind the trachea and in front of the sixth and seventh cervical vertebræ. This stage is very short. It lies to the left of the middle line, its left margin projecting beyond the trachea.

(2) *Superior mediastinal,* behind the trachea and left bronchus and in front of the upper four dorsal vertebræ. It passes towards the right of the middle line below.

FIG. 261.—TRANSVERSE SECTION OF THE POSTERIOR MEDIASTINUM AT THE LEVEL OF THE EIGHTH DORSAL VERTEBRA.



(3) *Posterior mediastinal,* behind the pericardium and in front of the aorta and sixth, seventh, eighth, and ninth vertebræ. It passes again to the left of the middle line as it reaches the diaphragm.

(4) *Abdominal,* in and below the diaphragm. This stage is about ¾ inch long.

Stages 1 and 4 are the only ones accessible for surgical operations. In the cervical stage the œsophagus is reached at its divergence to the left of the trachea.

In the *thorax* the œsophagus lies on the bodies of the vertebræ in a part of its course, but it is separated from them at the upper part by the longus colli, and at a lower level by the thoracic duct, azygos veins, right intercostal arteries, and, near its termination, by the thoracic aorta. The two vagi lie on its posterior mediastinal stage and form a plexus. *In front* it is covered by the trachea, left bronchus, and the pericardium. *Laterally* it is covered on its *right* side by the pleura; on its *left* side it is in contact with the descending aorta, and at its upper part with the thoracic duct. Above and below it is also in contact with the left pleura.

NARROWINGS.—The three narrowest points of the œsophagus are (1) at its commencement; (2) at its termination; (3) behind the left bronchus. At these three points caustic poisons leave their worst effects.

STRUCTURE.—The œsophagus is surrounded by a fibrous sheath, in which the vagi and œsophageal vessels form plexuses. When this is removed the thick coat of longitudinal muscle-fibres give it the appearance of a strap-like muscle. The longitudinal fibres are attached above by a fibrous expansion to the vertical ridge of the cricoid cartilage; below they end in the longitudinal muscular coat of the stomach. A circular coat lies beneath the longitudinal. The submucous coat is lax and allows the mucous coat to be thrown into folds when the œsophagus is undistended. The epithelium lining it is stratified.

BLOOD SUPPLY.—Arteries are derived from the inferior thyroid, descending aorta, and gastric arteries. They form an anastomotic chain along the œsophagus. The veins pass to the inferior thyroid, azygos veins, and gastric.

NERVES.—From the recurrent laryngeal and vagi.

The lymphatics pass to the gastric lymphatic glands, to those of the posterior mediastinum, to the bronchial and paratracheal groups. The bronchial glands, when diseased, frequently adhere to the coats of the œsophagus in its posterior mediastinal stage. The adhesions may give rise to diverticula.

The Thoracic Duct (figs. 261 and 262).—The thoracic duct extends from the upper part of the abdominal cavity, where it commences in the receptaculum chyli, to the root of the neck, and is about eighteen inches in length. Its walls are very thin; it is empty and collapsed, and may easily be mistaken for a vein. Communications take place between it and the azygos veins (Leaf). Hence if tied, or injured, the chyle may still reach the venous circulation through these veins.

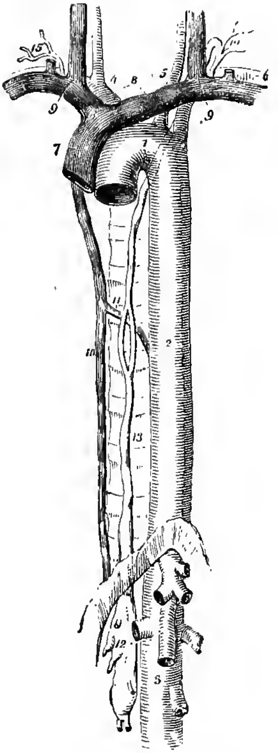
STAGES.—(1) *Abdominal*, lying in front of the twelfth dorsal, first and second lumbar vertebræ, between the right crus and aorta. It enters the next stage by the aortic orifice. It lies to the right of the aorta.

(2) *Posterior mediastinal*, lying on the lower eight dorsal vertebræ, between the aorta and vena azygos major.

(3) *Superior mediastinal.*—It crosses to the left side, behind the œsophagus and aortic arch, and lies between the œsophagus and left subclavian artery, in contact with the left pleura.

(4) *Cervical*, arching above the first stage of the left subclavian artery, over the vertebral vessels and scalenus anticus. It enters the commencement of the left innominate vein, between the jugular and subclavian veins.

FIG. 262.—THE COURSE OF THE THORACIC DUCT. (*Wilson.*)



1. Arch of the aorta. 2. Thoracic aorta. 3. Abdominal aorta, showing its principal branches divided near their origin. 4. Arteria innominata, dividing into right carotid and right subclavian. 5. Left carotid. 6. Left subclavian. 7. Superior cava, formed by the union of (8) the two venæ innominatæ; and these by the junction (9) of the internal jugular and subclavian vein at each side. 10. Greater vena azygos. 11. Termination of the lesser in the greater vena azygos. 12. Receptaculum chyli; several lymphatic trunks are seen opening into it. 13. Thoracic duct, dividing opposite the middle of the dorsal vertebræ into two branches which reunite; the course of the duct behind the arch of the aorta and left subclavian artery is shown by a dotted line. 14. The duct making its turn at the root of the neck and receiving several lymphatic trunks previously to terminating in the posterior aspect of the junction of the internal jugular and subclavian vein. 15. Termination of the trunk of the ductus lymphaticus dexter.

TRIBUTARIES.—The receptaculum chyli receives all the lymphatics of the lower extremities, pelvis and abdomen, excepting a few from the upper surface of the liver. The thoracic duct receives the lymphatics of the left side of the thorax, and some from the lower part of the right side of that cavity, from the left upper extremity and the left side of the head and neck.

The lymphatics of the right side of the thorax, the right upper extremity, and the right side of the head and neck enter the right lymphatic duct (fig. 262).

Lymphatic Glands in the Thorax. Several groups of lymphatic glands are met with in the thorax. Some of these are in relation to the chest-wall, while others lie within the thoracic cavity.

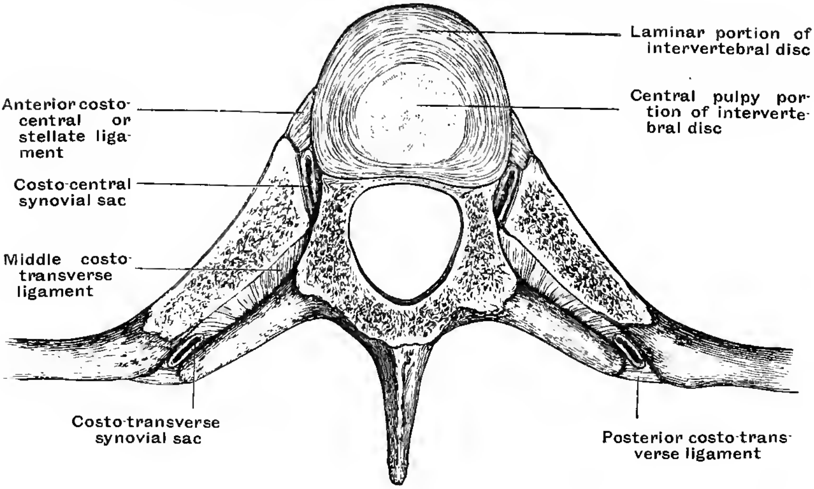
The *parietal* glands consist of two sets: the anterior intercostal or sternal, and the posterior intercostal glands. These lie in the anterior and posterior extremities of the intercostal spaces.

The glands found within the thorax are the *mediastinal* and *bronchial* glands.

The mediastinal glands consist of three sets, the anterior, posterior, and superior mediastinal glands, occupying positions in corresponding divisions of the mediastinum. The bronchial glands have already been considered.

DISSECTION.—The trachea, œsophagus, and diaphragm are to be cut away, the attachment and relationships of the last being carefully observed. Notice in particular that the pleura covers the vertebral half of the last pair of ribs. The margin of the lung, even in full inspiration, does not reach beyond the eleventh pair. The inferior fornix of the pleural cavity descends on the diaphragm, between the kidney in front and the twelfth rib behind. It may be opened accidentally during operations on the kidney. The azygos veins are again traced (p. 230), and removed with the thoracic duct and gangliate chain of the sympathetic.

FIG. 263.—HORIZONTAL SECTION THROUGH AN INTERVERTEBRAL DISC AND THE CORRESPONDING RIBS. (*From Morris's 'Anatomy.'*)


Laminar portion of intervertebral disc
Central pulpy portion of intervertebral disc
Anterior costo-central or stellate ligament
Costo-central synovial sac
Middle costo-transverse ligament
Costo-transverse synovial sac
Posterior costo-transverse ligament

Costo-vertebral Joints and Ligaments.—These require much cleaning. The student must not hesitate to use the bone forceps freely to expose them. The joints between the first, tenth, eleventh, and twelfth pairs of ribs and the vertebræ are atypical, and should be examined last. Each typical rib has two vertebral articulations, *costo-central* and *costo-transverse.*

Costo-central Articulations.—The head of a typical rib presents a ridge which is bound to the intervertebral disc by an *interarticular ligament* (fig. 264). Some of the posterior fibres of this ligament may be traced behind the disc towards the ligament of the opposite rib, forming the ligamentum conjugale. Above and below the interarticular ligament the head of the rib articulates with the margins of the adjacent vertebral centra or bodies, each margin having its own synovial facet.

The *stellate ligament* (fig. 264) (anterior costo-central) passes from the head of the rib to the vertebra above, the vertebra below, and the disc in which the head rests. Its deep surface is continuous with the interarticular ligament.

Costo-transverse Articulations.—The inner smooth part of the tubercle of a rib articulates with the smooth surface on the anterior upper aspects of the transverse processes. The joint has a capsular membrane, and is strengthened by three ligaments (fig. 263).

(1) The *posterior costo-transverse* ligament passes between the tip of the transverse process and the rough outer surface of the tuberosity. It is a ligament of great strength.

(2) The *middle costo-transverse* or interosseous ligament joins the adjacent surface of the neck of the rib and transverse processes together.

(3) The *superior costo-transverse* passes from the sharp ridge on the upper border of the costal neck to the transverse process above. Between its inner margin and the capsule of the articular processes there is a passage for the posterior branches of the dorsal arteries and nerves.

Atypical Costo-vertebral Joints.—First Pair of Ribs. The heads of the ribs articulate with the body of the first dorsal vertebra. Hence there is only one synovial costo-central cavity, and no interarticular ligament.

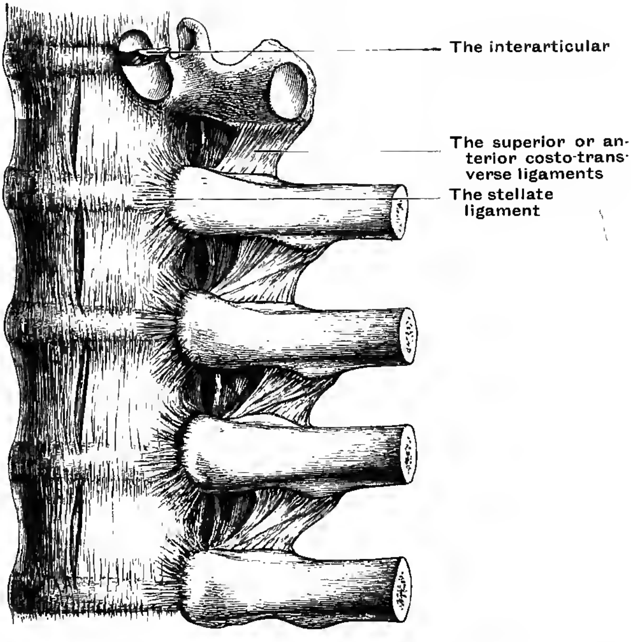
Tenth Pair of Ribs.—The heads articulate with the body of the tenth vertebra, with the same result as in the first pair.

Eleventh Pair.—The costo-transverse and costo-central articulations are close together, and the costo-vertebral movements are more free. The head articulates with the body of the eleventh vertebra.

TWELFTH PAIR.—The costo-transverse and costo-central articulations are fused. The rib is bound loosely to the short transverse process by ligamentous tissue.

MOVEMENTS OF THE RIBS.—A typical rib should be obtained and studied in connection with the costo-vertebral joints now opened. It will be plain that the heads of the ribs are firmly fixed in their joints and allow only a hinge-like movement; the tuberosities, on the other hand, allow some amount of gliding.

FIG. 264.—THE ANTERIOR COMMON LIGAMENT OF THE SPINE, STELLATE, INTERARTICULAR, AND SUPERIOR COSTO-TRANSVERSE LIGAMENTS. (*From Morris's 'Anatomy.'*)



There are two movements possible:

(1) *Sterno-vertebral.*—Each costal hoop is bent with its convexity outwards, and passes from the spine to the sternum, on which it may rotate on an axis joining its two extremities. During expiration the convexity of the hoop is

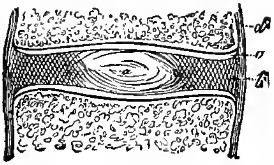
lowered; in inspiration it is raised, thus increasing the transverse diameter of the thorax (see p. 251).

(2) *Costo-vertebral.*—This movement takes place between the costo-central and costo-transverse joints. The neck of the rib is the axis of movement. On this axis the rest of the rib rises and falls during respiration, thus alternately increasing and decreasing the antero-posterior diameter of the thorax.

Intervertebral Foramina (fig. 264).—In these important foramina, the posterior root ganglia lie; the spinal nerves and veins emerge at them, the spinal arteries enter.

BOUNDARIES.—*Behind*, the articular processes and their capsular ligament. *In front*, the intervertebral disc and margins of the vertebræ. *Above and below*, the pedicles of the vertebræ, heads of the ribs and their ligaments.

FIG. 265.—DIAGRAM OF AN INTERVERTEBRAL DISC DIVIDED VERTICALLY. (*Wilson.*)



At *a*, the pulpy centre; at *b*, the fibrous ring; at *c*, the cartilaginous covering of the body of the vertebra; *d*, the periosteum.

Passage for Posterior Divisions of Vessels and Nerves. — It is bounded *externally* by the superior costo-transverse ligament; *internally* by the articular process and capsule; *above* and *below* by the roots of the transverse processes.

Dorsal Vertebral Ligaments.—The *anterior common ligament*, composed of longitudinal bundles of fibres, covers the bodies of the dorsal vertebræ, being strongest and best marked in front of the bodies. It becomes wider and stronger as it passes downwards. It is narrowest at the fourth dorsal vertebra. Below, the crura of the diaphragm fuse with it. Its attachment is firmest to the discs and margins of the vertebræ.

The *Intervertebral Discs* become deeper as they approach the lumbar region. They should be examined in transverse and horizontal sections (figs. 263, 265). Within is a central pulpy mass; concentric layers of fibrous tissue enclose it. The fibres of one layer run at an angle to those of adjacent layers and bind the bodies together. The disc is fixed to the vertebræ by a plate of cartilage (fig. 265). The bodies of the vertebræ are weaker than the discs; a disc is rarely torn in fracture of the spine.

The *posterior common ligament*, which descends on the posterior surfaces of the bodies of the vertebræ within the spinal canal, becomes stronger as it approaches the cervical region. It is weaker than the anterior ligament. It is wide opposite the discs and vertebral margins, where it is attached, and narrow over the bodies, where it is free.

Interarticular Joints.—The articular processes overlap each other, and are provided with synovial articular cavities. A strong capsule unites them, and allows a gliding movement.

The **movements** allowed in the dorsal region of the spine are: ROTATION. The movement of rotation of one dorsal vertebra on another is limited, but when the collective movements are added it is considerable. The bodies are fixed by their discs; rotation takes place behind them at the articular processes, which are set so as to allow this to take place.

FLEXION.—Only a limited amount of flexion is allowed, either to the front or to the side in the upper dorsal region; the sternal ribs and sternum prevent such movements. But the dorso-lumbar region, on the other hand, allows the freest lateral and dorso-ventral flexion. This is the region most liable to fracture.

Other ligaments, besides those just named, unite the dorsal vertebræ together. They are the ligamenta subflava, the interspinous, supra-spinous, and inter-transverse, and are examined by the dissectors of the head and neck.

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